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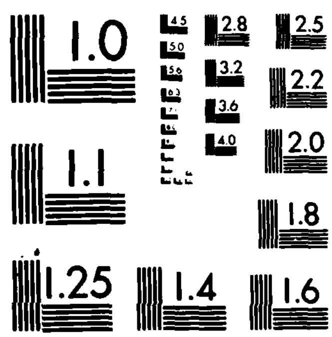

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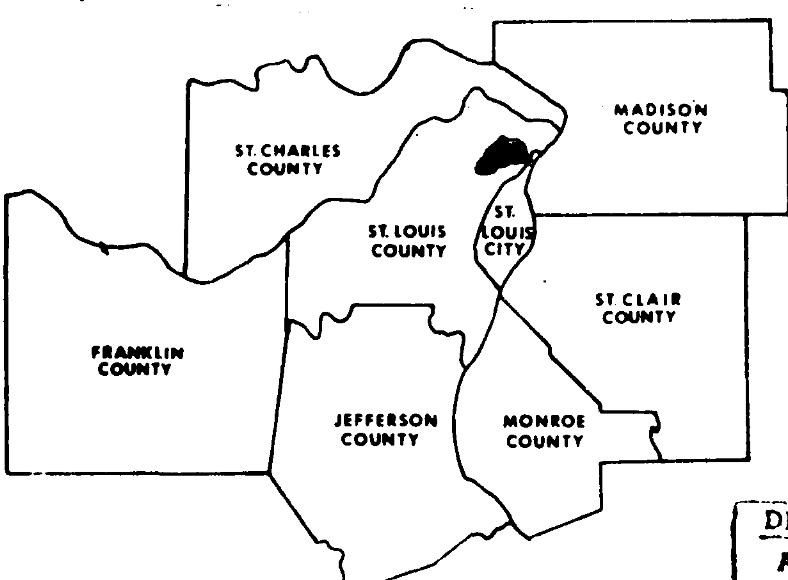
WATER RESOURCES INVESTIGATION
ST. LOUIS METROPOLITAN AREA
MISSOURI AND ILLINOIS

MALINE CREEK, MISSOURI
SURVEY REPORT

AD-A140 671



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ST. LOUIS, MISSOURI
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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)
This report recommends an environmentally designed, outdoor recreation-oriented solution to the flooding problems along Maline Creek. Maline Creek is best described as an urban storm sewer. The stream's natural features have been essentially eliminated by intense urbanization. The 25 square mile study area is located from the Lambert St. Louis International Airport, eastward through urbanized St. Louis County and the city of St. Louis, Missouri, to the

Mississippi River. The object of this study is to identify comprehensively all alternative options and to recommend a solution to the problems normally associated with urban stormwater sewers such as: flooding; streambank erosion; lack of outdoor recreation; and, environmental degradation.

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A	PROBLEM IDENTIFICATION
B	FORMULATION, ASSESSMENT AND EVALUATION OF DETAILED PLANS
C	PUBLIC VIEW AND RESPONSES
D	HYDRAULICS AND HYDROLOGY
E	DESIGN AND COST ESTIMATES
F	RECREATION AND FISH AND WILDLIFE RESOURCES
G	SOCIAL AND CULTURAL RESOURCES
H	ECONOMICS
I	ENDANGERED SPECIES
J	CLEAN WATER ACT (SECTION 404)

WATER RESOURCES INVESTIGATION

ST. LOUIS METROPOLITAN AREA, MISSOURI AND ILLINOIS

MALINE CREEK, MISSOURI

SURVEY REPORT FOR FLOOD CONTROL AND ALLIED PURPOSES

VOLUME TWO - APPENDICES

WATER RESOURCES INVESTIGATION

ST. LOUIS METROPOLITAN AREA, MISSOURI AND ILLINOIS

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PROBLEM IDENTIFICATION

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PROBLEM IDENTIFICATION

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APPENDIX A

PROBLEM IDENTIFICATION

1. This appendix addresses the purpose, authority, and scope of the study. In addition, information is included discussing: the study participants and coordination; an introduction to the content and format of the entire report; prior studies and reports; existing and future without project conditions; problems, needs and opportunities identified; and planning constraints and objectives.

PURPOSE AND AUTHORITY

2. The purpose of this preauthorization survey report has been to investigate the flooding and allied water resource problems of the Maline Creek watershed, Missouri. Presented in this report is an identification and assessment of flooding and allied water resource problems and needs in the Maline Creek watershed, an analysis of the plausible alternative plans, and an identification of a recommended plan of improvements. The authority for this study predates and also stems from the St. Louis District, Corps of Engineers' more comprehensive regional report entitled the "St. Louis Metropolitan Area, Missouri and Illinois, Study" (Metro Study). Therefore, this study represents only a partial response to the following six resolutions:

United States Senate
Committee on Public Works

COMMITTEE RESOLUTION

RESOLVED BY THE COMMITTEE ON PUBLIC WORKS OF THE UNITED STATES SENATE, That the Board of Engineers for Rivers and Harbors, created under Section 3 of the River and Harbor Act approved June 13, 1902, be, and is hereby requested to review the report of the Chief of Engineers on the Mississippi River at St. Louis, Missouri, published as Senate Document Numbered 57, Eighty-fourth Congress, and other pertinent reports, with a view to determining whether any modifications of the recommendations contained therein are advisable at this time, with particular reference to providing improvements in the interest of flood control and other allied purposes, in the Columbia Bottoms area at the confluence of the Missouri-Mississippi Rivers.

Adopted: April 7, 1966 /S/

PAT. McNAMARA, U.S.S., Chairman

(At the request of Senators Stuart Symington and Edward V. Long of Missouri)

United States Senate
Committee on Public Works

COMMITTEE RESOLUTION

RESOLVED BY THE COMMITTEE ON PUBLIC WORKS OF THE UNITED STATES SENATE, That the Board of Engineers for Rivers and Harbors, created under Section 3 of the River and Harbor Act approved June 13, 1902, be, and is hereby requested to review the report of the Chief of Engineers on the Mississippi River at St. Louis, Missouri, published as Senate Document Numbered 57, Eighty-fourth Congress, and other pertinent reports, with a view to determining whether any modifications of the recommendations contained therein are advisable at this time, with particular reference to providing improvements in the interest of flood control on tributary streams within the Metropolitan St. Louis Sewer District, St. Louis and vicinity, Missouri.

Adopted: October 4, 1966 /S/______________________
Jennings Randolph Chairman

(At the request of Senators Stuart Symington and Edward V. Long of Missouri)

United States Senate
Committee on Public Works

COMMITTEE RESOLUTION

RESOLVED BY THE COMMITTEE ON PUBLIC WORKS OF THE UNITED STATES SENATE, That the Board of Engineers for Rivers and Harbors, created under Section 3 of the River and Harbor Act approved June 13, 1902, be, and is hereby requested to review the report of the Chief of Engineers on the Mississippi River at St. Louis, Missouri, published as Senate Document Numbered 57, Eighty-fourth Congress, and other pertinent reports, with a view to determining whether any modifications of the recommendations contained therein are advisable at this time, with particular reference to providing improvements in the interest of flood control and other water and related land resource purposes, on tributary streams within the Metropolitan St. Louis Sewer District, St. Louis and vicinity, Missouri.

Adopted: July 15, 1970 /S/
Jennings Randolph Chairman

(At the request of Senators Stuart Symington and Thomas F. Eagleton of Missouri)

Committee on Public Works
U.S. HOUSE OF REPRESENTATIVES
Washington, D.C. 20515

RESOLUTION

Resolved by the Committee on Public Works of the House of Representatives, United States, that the Board of Engineers for Rivers and Harbors, created under Section 3 of the River and Harbor Act approved June 13, 1902, be, and is hereby requested to review the report of the Chief of Engineers on the Mississippi River at St. Louis, Missouri, published as Senate Document Numbered 57, Eighty-fourth Congress, and other pertinent reports, with a view to determining whether any modifications of the recommendations contained therein are advisable at this time, with particular reference to providing a plan for the development, utilization, and conservation of water and related land resources of St. Louis County and the City of St. Louis, Missouri, including, but not limited to, consideration of the needs for flood control, wise use of flood plains lands, wastewater management facilities, regional water supply, water quality control, recreation, fish and wildlife conservation, and other measures for enhancement and protection of the environment on streams tributary to the Meramec, Missouri, and Mississippi Rivers.

Adopted: July 29, 1971

Attest: /S/ John A. Blatnik

Requested by: Hon. Ichord, Hon. Symington, Hon. Hungate

United States Senate
Committee on Public Works

COMMITTEE RESOLUTION

RESOLVED BY THE COMMITTEE ON PUBLIC WORKS OF THE UNITED STATES SENATE, that the Board of Engineers for Rivers and Harbors, created under Section 3 of the River and Harbor Act approved June 13, 1902, be, and is hereby requested to review the report of the Chief of Engineers on the Mississippi River between Coon Rapids Dam and the mouth of the Ohio River, published as House Document Numbered 669, Seventy-sixth Congress, third session, and other pertinent reports, with a view to determining whether any modifications of the recommendations contained therein are advisable at this time, with particular reference to providing a plan for the development, utilization, and conservation of water and related land resources of the metropolitan area of St. Louis, Missouri, with due consideration for the metropolitan planning activities in the area consisting of Franklin, Jefferson, St. Charles, and St. Louis Counties and the city of St. Louis in Missouri, and Madison, Monroe, and St. Clair Counties in Illinois. Such study to include, but not be limited to, consideration of the needs for flood control, wise use of flood plain lands, wastewater management facilities, including stormwater runoff, regional water supply, water quality control, recreation, fish and wildlife conservation, protection and enhancement of esthetic qualities, and other measures for enhancement and protection of the environment on streams in the metropolitan area. Investigation to be conducted in cooperation with the East-West Gateway Coordinating Council, the States of Missouri and Illinois, local governmental entities, and other interested Federal, State, and local agencies, as appropriate.

Adopted: October 2, 1972 /S/ ____________________
Jennings Randolph Chairman

(At the request of Senators Symington and Eagleton of Missouri and Senators Percy and Stevenson of Illinois)

Committee on Public Works
U.S. HOUSE OF REPRESENTATIVES
Washington, D.C. 20515

RESOLUTION

Resolved by the Committee on Public Works of the House of Representatives, United States, that the Board of Engineers for Rivers and Harbors, created under Section 3 of the River and Harbor Act approved June 13, 1902, be, and is hereby requested to review the report of the Chief of Engineers on the Mississippi River between Coon Rapids Dam and the mouth of the Ohio River, published as House Document Numbered 669, 76th Congress, 3rd Session, and other pertinent reports, with a view to determining whether any modifications of the recommendations contained therein are advisable at this time, with particular reference to providing a plan for the development, utilization, and conservation of water and related land resources of the metropolitan area of St. Louis, Missouri, with due consideration for the metropolitan planning activities in the area consisting of Franklin, Jefferson, St. Charles, and St. Louis Counties and the city of St. Louis in Missouri, and Madison, Monroe, and St. Clair Counties in Illinois. Such a study to include, but not be limited to, consideration of the needs for flood control, wise use of flood plain lands, wastewater management facilities, including stormwater runoff, regional water supply, water quality control, recreation, fish and wildlife conservation, protection and enhancement of esthetic qualities, and other measures for enhancement and protection of the environment on streams in the metropolitan area. Investigation to be conducted in cooperation with the East-West Gateway Coordinating Council, the States of Missouri and Illinois, local governmental entities, and other interested Federal, State, and local agencies, as appropriate.

Adopted: October 12, 1972

Attest: /S/__________________
John A. Blatnik, M.C.
Chairman

Requested by: Hon. Melvin Price

SCOPE OF THE STUDY

3. The studies presented in this report address the entire area within the boundaries of the Maline Creek watershed. These studies were made in the depth and detail needed to comprehensively analyze the watershed's water and land-related resource problems and potential solutions so as to permit plan selection and to determine feasibility. Initially, all reasonable solutions were considered. All of the most promising alternatives were then studied in greater detail. The selection of the most feasible plan was made after considering all factors, including the views expressed by concerned agencies, the State of Missouri, the local communities, and other local interests.

STUDY PARTICIPANTS AND COORDINATION

4. The Corps of Engineers has the overall responsibility for this study.

5. Early in the study, an active public involvement and interagency coordination program was identified as a necessity in this urban setting to insure effective plan formulation. With the assistance of the Institute for Water Resources, a three-level public participation and agency coordination program was developed. This three-level technique was used to coordinate the study progress with all appropriate Federal, state, and local agencies, as well as interested public groups and individuals. The three levels of coordination pursued were as follows:

(a) Level one coordination activities include organizations that have broad regional interests, significant technical expertise, and important socio-political input. At this level, the following

agencies participated in the study: the Metropolitan St. Louis Sewer District; the East-West Gateway Coordinating Council; St. Louis County; Bureau of Outdoor Recreation; Soil Conservation Service; United States Geological Survey; Forest Service; Department of Housing and Urban Development; United States Fish and Wildlife Service; National Park Service; United States Coast Guard; Federal Highway Administration; Federal Aviation Administration; Federal Power Commission; Environmental Protection Agency; and the State of Missouri. In addition to providing valuable review comments, the Environmental Protection Agency conducted a Maline Creek water quality study; the Bureau of Outdoor Recreation supplied assistance with recreation analyses; the Soil Conservation Service conducted a soils mapping program for the Maline Creek watershed; and the United States Geological Survey supplied recorded rainfall and streamflow data. In addition, the Metropolitan St. Louis Sewer District, the East-West Gateway Coordinating Council, St. Louis County, and the Corps of Engineers formed an informal organization called the Maline Creek Guidance Committee. Throughout the planning process, this Guidance Committee met to discuss the alternative plans and to provide input towards shaping the final recommendation.

(b) Level two coordination activities include organizations and groups with a more limited jurisdiction or special expertise and interest. This group includes municipally elected officials, professional engineering and planning groups, and environmental groups. Meetings were held periodically to keep this level informed on the progress of the study.

(c) Level three involves the directly affected individual citizen and neighborhood groups. Input from this level, as well as from levels one and two, was formally received at public meetings

held on 14 June 1968, 18 October 1972, and 15 July 1980, and also informally received via numerous individual telephone and field contacts. These informal meetings were particularly effective in providing a mechanism for two-way communications with affected individuals and organizations. Input obtained in this manner was essential in identifying problems, needs, impacts, and evaluations.

PRIOR STUDIES AND REPORTS

6. No Federally authorized water resource studies or prior reports have been prepared by the Corps of Engineers addressing the entire Maline Creek watershed. However, a report the St. Louis District prepared in response to a resolution adopted on 20 April 1948 by the United States Senate, Committee on Public Works, addressed improvements at the mouth of Maline Creek as part of the city of St. Louis and Vicinity, Missouri, project. Subsequent known reports discussing the lower Maline Creek area in relation to the above project are: "Senate Document Numbered 57, Eighty-fourth Congress, First Session;" "House Document Numbered 669, Seventy-sixth Congress, Third Session;" "Design Memorandum No. 4, General Design, Corps of Engineers, October 1957;" "Preliminary Investigation - Flood Protection Along Maline Creek - City of St. Louis and Vicinity, Missouri, Corps of Engineers, June 1961;" and "Flood Protection - St. Louis, Missouri, Design Memorandum, Floodwalls, Levees, and Pumping Station, Reach 3, Maline Creek - Area B, FRUCO and Associates, 1963."

7. Other Federal agencies have participated in water resource oriented work efforts in the Maline Creek drainage basin. The Department of Housing and Urban Development has provided funds to channelize portions of Maline Creek, reroute other portions, and

encase portions of a tributary in underground pipes. These efforts were accomplished in order to handle immediate problems of a very localized nature and have no major impact on the recommendations made by this report.

8. At the local level, information based on extensive field experience provided by the Metropolitan St. Louis Sewer District and St. Louis County has been extremely helpful during the course of this investigation.

9. In addition to the above, flood insurance studies for the following municipalities within the Maline Creek watershed have been completed as of September 1980: Bellefontaine Neighbors, Bel Ridge, Berkeley, Black Jack, Cool Valley, Ferguson, Florissant, Jennings, Kinloch, Moline Acres, Overland, and Vinita Park.

THE REPORT AND STUDY PROCESS

10. In the interest of clarity of presentation and reference, this report has been arranged into a main report and technical appendixes. The main report is a non-technical summary of the entire Maline Creek study. It is the basic document that presents a broad overview of the complete study for the benefit of both general and technical readers. The main report includes a description of the study area, including existing and alternative future problems and needs within the watershed; the plan formulation process; a summary of the project economics, including the benefits, costs, and justification; the division of plan responsibilities between Federal and non-Federal interests; and recommendations for implementing the selected plan.

11. The technical appendixes address the same topics as the main report, except that the technical appendixes cover important study activities in much greater detail for the technical reviewer.

12. The multi-objective planning framework as described in the ER 1105-2-200 series provided the guidance for conducting feasibility studies for water and related planned resources consistent with the planning requirements of the WRC Principles and Standards (P&S), the National Environmental Policy Act of the 1969 (NEPA) and related policies. The process establishes a methodology under which alternative plans are formulated and the resulting economic, social, and environmental impacts are assessed and evaluated. The Maline Creek Study was conducted under this guidance.

13. The P&S require that Federal water and related land planning be directed to achieve National Economic Development (NED) and Environmental Quality (EQ) as equal national objectives. NED is to be achieved by increasing the value of the nation's output of goods and services and improving national economic efficiency; EQ is to be achieved by the management, conservation, reservation, creation, restoration, or improvement of the quality of certain natural and cultural resources and ecological systems. The P&S also require that the impact of a proposed action be displayed and accounted for in terms of contributions to four accounts. The four accounts are: National Economic Development, Environmental Quality, Regional Development, and Social Well-Being.

14. To accomplish the goals and objectives of the multi-objective planning framework, the study process was divided into three sequential stages. The three stages are: Reconnaissance, Development of Intermediate Plans, and Development of Detailed Plans. Within each of these three stages, four planning tasks were

carried out. The four planning tasks are: Problem Identification, Formulation of Alternatives, Impact Assessment, and Evaluation. It should be noted that while each of the four tasks were carried out in each stage, there is different emphasis placed on each task in each stage. For instance, during Stage 1 the major emphasis was on Problem Identification (Task 1). There was effort devoted to the formulation of alternatives and impact assessment and evaluation, but the major effect was on Task 1. During Stage 2, the major emphasis was on forumulation of alternatives and associated impact assessment and evaluation. During Stage 3, Development of Detailed Plans, the alternatives carried forward from Stage 2 were refined and detailed but the major emphasis was on impact assessment and evaluation leading toward plan selection and recommendation.

NATIONAL OBJECTIVES

15. As mentioned in the previous paragraphs, this study was accomplished following the guidance of the Water Resource Council's principles and Standards (P&S). The P&S require that Federal water and related land planning be directed to achieve National Economic Development (NED) and Environmental Quality (EQ) as equal national objectives. NED is to be achieved by increasing the value of the nation's output of goods and services and improving national economic efficiency. EQ is to be achieved by the management, conservation, reservation, creation, restoration or improvement of the quality of certain natural and cultural resources and ecological systems. Specifically, NED is evaluated using the benefit-cost analysis and EQ is evaluated using the System of Accounts.

16. In addition to the two national objectives stated, P&S require that all impacts of proposed action be measured and the results displayed in terms of contributions to four accounts: National Economic Development, Environmental Quality, Regional Development (RD) and Social Well-Being (SWB). The NED and EQ accounts have already been discussed. Contributions to the RD accounts are determined by establishing a proposal's effects on the region's income, employment, population, economic base, environment and social development. Contributions to the SWB account are determined by establishing a proposal's effects on the region's income, employment, population, economic base, environment and social development. Contributions to the SWB account are determined by establishing a proposal's effects on the real income, security of life, health and safety, educaton, cultural and recreational opportunities, emergency preparedness and other factors.

EXISTING CONDITIONS (PROFILE)

17. In order to establish a frame of reference for subsequent discussions contained within this report, the following presents information about the environmental, natural, and human resources of the watershed as well as details about its development and economy. The information was obtained through literature searches, data research contracts, and Corps of Engineers' observations within the watershed. All known sources of information are cited where appropriate and are on file in the St. Louis District Corps of Engineers' offices.

18. Maline Creek enters the Mississippi River at River Mile 187.2, approximately 8 miles downstream from the confluence of the Mississippi and Missouri Rivers (PLATE A-1). The Maline Creek watershed covers 16,170 highly urbanized acres, including a small part of the city of St. Louis, portions of unincorporated St. Louis County, and all or parts of 22 municipalities within St. Louis County (See TABLE A-1 and PLATE A-2).

Geology and Soils

19. In the National Atlas, "Classes of Land-Surface Form," Hammond (1969) classified the watershed as an "Irregular Plain." This means that 50 to 80 percent of the area is gently sloping, and from 50 to 75 percent of this gentle slope is on the upland surface. The local relief for the basin is less than 300 feet, and the mean slope of the longest portion of Maline Creek is about one foot of vertical drop in 220 feet.

TABLE A-1
MALINE CREEK

MUNICIPALITIES

Bellefontaine Neighbors	Charlack	Moline Acres
Bellerive	Cool Valley	Normandy
Bel-Nor	Dellwood	Overland
Bel-Ridge	Ferguson	Pasadena Park
Berkeley	Florissant	Riverview
Black Jack	Jennings	St. John
Calverton Park	Kinloch	Sycamore Hills
		Vinita Park

20. The St. Louis metropolitan area lies on or near several physiographic and structural divisions. The watershed lies within the Till Plains section of the Central Lowlands physiographic province. Structurally, the Maline Creek watershed is influenced by the Ozark Dome to the west and the Illinois Basin to the east. A variety of structures in the region take the form of alternating anticline and synclines with northwest-southeast trending axes: the Florissant Dome and the St. Louis Fault (axis, N11^{o}E). Further north of St. Louis lies the Cap au Gris Faulted Flexure and another anticline/syncline system. The rock foundations within the watershed slope only to a minor extent.

21. The highest bedrock in the Maline Creek watershed is Pennsylvanian of the Maramton or older Cherokee Group. Pennsylvanian shales/limestones constitute a major unconformity below the Cherokee Group. Several formations were removed down to the Ste. Genevieve, which is the youngest of the Meramecian Series. The remaining bedrock down to the Precambrian (3,000 feet) is cyclical deposits of interbedded limestone/dolomites, sandstones, and shales.

22. The principal material over bedrock in the Maline Creek watershed is a thick (30- to 50-foot) deposit of loess. Loess is a windblown, glacial age silt deposit. In lower reaches of the stream, the flood plain consists of alluvial material derived from the adjacent loess. Pure loess is characterized by very uniform-sized silt particles, yellow to brown in color, and a weakly cemented structure which gives it the unique characteristic of being able to stand in very steep or vertical banks. If disturbed or saturated, it loses its structure and most, if not all, of its vertical strength. Loess in the Maline Creek watershed is

frequently clay rich, particularly at more extreme depths. The Missouri Geological Survey indicated that two distinct loess formations are usually present (Lutzen and Rockaway, 1971). The overlying Peoria loess is relatively thin (5-10 feet) and clay rich. Because of the lower permeability of the underlying Roxana loess, downward migrating moisture collects at the contact. Moisture content in the lower loess formation may commonly be 5 to 10 percent higher than the upper loess.

23. The Unites States Department of Agriculture, Soil Conservation Service (SCS) is presently accomplishing a detailed soils survey of St. Louis County. Upon request from the Corps of Engineers, the SCS surveyed the Maline Creek watershed early in their work schedule. Copies of their field sheets were provided to the Corps of Engineers for planning purposes. Six broad soil types occur in the watershed (See PLATE A-3): Winfield and Menfro Silt Loam (1 and 2); altered Menfro-Winfield (18); urban land upland; a non-soil type (7) and two lowland soils - Iva Silt Loam (a terrace soil (52)) and flood plain (low terrace (20)). Both Menfro and Winfield series occupy upland positions, and are derived from thick loess. They consist primarily of silt loams, and are moderately well drained to well drained. The 18 and 7 units represent upland soils (originally Menfro and Winfield) that have been altered by urbanization. At its most extreme expression, the urbanization ranges from complete removal of soil in some areas to filling in 30 feet or more of soil in others. More commonly, much smaller amounts of material have been excavated or filled in. On steep slopes, terracing has been done. A terraced slope will contain alternating bands of nearly level and steep slopes designed so as to minimize erosion impacts. The 20 mapping unit is in the flood plain and includes areas ranging from low places along the stream to terrace positions that may flood only once in 100 years. The Iva Silt Loam is a higher terrace soil.

Both the 20 and 52 units can be expected to have a high water table in the late winter and spring and other periods of high rainfall. Their dominant texture is silt loam at the surface and silt loam or silty loam in the subsoil.

24. In addition to the SCS mapping, the Photographic Interpretation Corporation of Hanover, New Hampshire, and the Corps of Engineers further investigated surficial material by stereoscopic interpretation of low-altitude airphotos flown in April [illegible]. The photo interpretation verifies the thick loessial cover in the basin indicated by detailed mapping and other published data. The loessial materials are indicated by gentle slopes, rounded hilltops, widely spaced tributaries, light, uniform photo tones, and steeply sided, U-shaped gullies.

25. One of the advantages of the iterative planning process being used for this study is that the detailed subsurface analysis need not be pursued until specific improvements have been identified, justified, and authorized. This planning technique, therefore, obviates the need for expensive detailed original subsurface exploration at the survey report level (i.e., for this report). Consequently, existing boring logs from other sources were obtained and analyzed to supplement the regional data discussed above. These included borings accomplished by the Corps of Engineers in connection with bank repair studies, bridge borings taken for the St. Louis County Highway Department, and other boring information provided by local engineers. While these borings were widely scattered on various tributaries and portions of the main channel, the soil profiles were very similar. In every case, the soils consist of silts, clays, or mixtures thereof, all the way to bedrock. Bedrock is located well below the creek bottom, varying

from a depth of 5 to 10 feet near the headwaters to 25 feet or more along the main channel. Bedrock, where identified, is usually shale. Soil profiles generally tend toward silty (Peoria loess) near the surface and become more clayey (Roxana loess) with depth. In some cases, man-made fill may be present above the natural soils.

Natural Resources

26. Mineral resources of economic importance found in and adjacent to the Maline Creek watershed include the St. Louis limestone and Lagonda shale. These deposits are quarried by the Missouri Portland Cement Company to obtain raw materials for cement. Very little coal has been produced in the region, although thin and irregular coal seams are present within the Pennsylvanian age rocks. The reserves of mineable coal are negligible and have not been estimated. No coal mining is expected within the region in the future (Wharton, et al., 1969).

27. In 1953, oil was discovered near the Florissant Dome which is adjacent to the Maline Creek watershed. The Florissant Dome pool has been a major producing area in the State of Missouri since its initial discovery in the Kimmswick Formation. The Laclede Gas Company operates a gas storage field in the St. Peter sandstone, in the vicinity of the Florissant Dome. The possibility of future additional oil discoveries near the Florissant Dome pool are considered "fair" geologically, but Wharton, et al., (1969) predicts that urbanization will hamper or eliminate active exploration.

28. Fresh water of limited yields is available from the Pennsylvanian age bedrock which underlies the watershed. The yield of fresh water from wells in the area is usually less than 10

gallons per minute. Miller, et al., (1974) included the Maline Creek watershed in the Post-Maquoketa aquifer group, in that the Maquoketa shale probably acts as a confining bed for the downward percolation of water. Mineralized water is obtained at depths greater than 500 feet. There are a few wells in north St. Louis County extending to as much as 2,800 feet. These deeper wells yield groundwater which does not meet the chemical drinking water standard.

Drainage

29. The principal surface drainage system within the watershed is 36.2 miles long in total and consists of the main channel of Maline Creek and ten tributaries (See PLATE A-4). The main channel is 10.6 miles long and extends about 7 miles west from its confluence with the Mississippi River. The ten major tributaries vary in length from 1.4 miles to 4.2 miles and have a combined length of 25.6 miles. There are widespread variations in the size and configuration of the drainage channels. The headwater channels are predominantly storm sewers which subsequently flow into open channels reaching a maximum size of 25 feet deep and 100 feet wide near the mouth. There are numerous constrictions to the natural drainageways. Spanning the channels are a total of 62 bridges and culverts. Major bridges across the main channel (from east to west) include the Burlington Northern Railroad; three abandoned bridge structures side-by-side just downstream from Riverview Drive; Riverview Drive; Bellefontaine Road; U.S. 367; Halls Ferry Road; Lucas and Hunt Road; Glenowen Drive; West Florissant Avenue; the Norfolk and Western Railroad; Irvington Avenue; North Hanley Road (formerly Carson Road); Interstate 70; Rolling Drive; Natural Bridge Road; Ramona Avenue; and St. Charles Rock Road. Surface channels are predominantly natural. However, some sections of the main

channel and its tributaries have been straightened. Some tributary channels have been concrete lined, and a few areas have been inclosed in culverts to accommodate land development or increase usable open space. Two distinct drainage patterns can be seen in the Maline Creek watershed (See PLATE A-5). In the eastern and central portion of the watershed, the main channel is oriented in an east-west direction. The relatively long straight tributaries meet the main channel at right angles from the north and very short tributaries enter from the south. The angularity of the pattern strongly suggests bedrock control. Therefore, it appears reasonable to assume that the eastern and central Maline Creek drainage pattern developed on the pre-glacial bedrock surface. The western portion of the watershed exhibits none of the indicators of bedrock control. Rather, it is characterized by a regular dendritic pattern, indicating that downcutting has not advanced enough to enable bedrock to be an influential drainage pattern factor.

Water Quality

30. The Missouri Department of Natural Resources, Environmental Quality Section, prescribes water quality standards which must be maintained for all waters of the state. For streams with small watersheds like Maline Creek, a set of "General Criteria" has been established. The "General Criteria" prescribe that the waters of the state shall be free from municipal, industrial, or agricultural effluents that are unsightly, odorous, or harmful to human, animal, or aquatic life. For many of the larger streams in the state, a series of "Specific Criteria" has been established, which prescribe the minimum values which must be maintained for certain water quality parameters. The results of the Corps of Engineers' water

quality studies of Maline Creek were compared with both the "General Criteria" and "Specific Criteria." In addition to the State of Missouri criteria, two other sources were reviewed for possible standards against which to evaluate the quality of water in Maline Creek. Pertinent values were taken from the U.S. Environmental Protection Agency (1973) publication "Proposed Criteria for Water Quality." Unpublished records of water quality measurements for various St. Louis District projects were reviewed to determine probable polluted/unpolluted threshold values for some parameters. It is recognized that only Missouri's "General Criteria" officially apply to Maline Creek for compliance purposes. Nevertheless, all sources of review are considered pertinent to the overall evaluation of the watershed's water quality.

31. The water quality of Maline Creek was tested and evaluated during three recent studies, either conducted by or done by contract for the Corps of Engineers. The Corps of Engineers conducted a monthly water quality monitoring program from May 1971 to September 1972 (U.S. Army Corps of Engineers, 1972). During the week of 15-19 November 1971, water quality was sampled on a daily basis from five of the seven Corps of Engineers' monitoring sites, plus nine additional sites, in a joint study conducted by the Corps of Engineers and the U.S. Environmental Protection Agency (EPA) (Environmental Protection Agency, 1972). In the spring of 1976, personnel from Southern Illinois University-Edwardsville (SIU) were hired by the Corps of Engineers to test water quality during a low water period and during a high water period (Office of Research and Projects, 1976). The parameters tested and the sampling sites generally coincided with the previous studies. The parameters measured during all three studies are given in TABLE A-2. The sampling sites are shown in PLATE A-6.

32. In the summer of 1976, the Metropolitan St. Louis Sewer District (MSD) conducted a field reconnaissance of Maline Creek, recording the flows from outfalls, the types of effluents entering the creek, and the occurrence of litter (Metropolitan St. Louis Sewer District, 1976). Tests were run on water quality samples from a limited number of their survey sites. The MSD study has been used to supplement the three studies conducted by or for the Corps of Engineers. The following paragraphs discuss the results of these three studies.

a. CORPS OF ENGINEERS STUDY. During the Corps' water quality monitoring program, water quality in Maline Creek ranged from fair to poor, depending on location and sampling time. Phosphorus and nitrogen levels were moderately high, indicating possible contamination from domestic wastes, industrial wastes, or fertilizers. Extremely low dissolved oxygen concentrations were prevalent during summer low flow periods. Turbidity concentrations were extremely low, except during high runoff periods when values of 200 JTU were observed. Chloride concentrations were relatively low, except during the winter months when salt from the urban streets was washed into the creek. High coliform bacteria concentrations at Kinloch were indicative of fecal wastes (human or livestock).

b. CORPS-EPA STUDY. The joint CORPS-EPA study revealed extremely high concentrations of macronutrients (nitrogen and phosphorus) in most reaches of Maline Creek, lending further evidence to the possibility of pollution from domestic, industrial, and agricultural sources. High fecal coliform densities cultured from the Maline Creek water after a moderate rain indicated a potential public health hazard between sampling stations at North

Hanley Road and Glenowen Drive. Because of the Metropolitan Sewer District's on-going efforts to address any and all identified point source fecal coliform problems, such conditions are expected to be handled expeditiously. However, non-point fecal coliform problems are expected to take longer to resolve. All sampling stations where heavy metals were sampled were found to have concentrations which are potentially toxic to aquatic life if allowed to accumulate.

c. CORPS STUDY (SIU). The Corps of Engineers' Study executed by SIU concluded that during low flow, Maline Creek appeared to be fairly unpolluted, with respect to dissolved organics, other nutrients, heavy metals, and chlorinated hydrocarbons. The one exception was the site nearest the mouth of Maline Creek, which shows the effect of a discharge of considerable amounts of lime. During high flow, general trends in parameter concentrations found during low flow were repeated. Alkalinity, heavy metals, and suspended solids were reduced as a result of dilution, but turbidity was increased. A dramatic increase in oxygen demand and nutrients was observed, due to organic material in the stormwater runoff. Nevertheless, concentrations of contaminants were at sufficiently low levels that the Corps of Engineers' study conducted by SIU concluded that Maline Creek was not classified as "polluted," even during this period of runoff. With respect to contamination of Maline Creek with human and livestock waste, interpretation of the total coliform counts and the fecal coliform/fecal streptocci ratios indicated that of the six stations sampled at low water, stations 3, 5, and 6 could be classified as polluted and containing fecal waste of human origin. Sites 1, 2, and 4 were contaminated by livestock waste. High water conditions showed a marked increase in the numbers of all three types of waste indicator bacteria and showed that five of the six sites can be considered polluted.

TABLE A-2
MALINE CREEK
WATER QUALITY AND SEDIMENT MEASUREMENTS FROM MALINE CREEK

Study[1]/Parameter[2]	Sampling Site								Standard[3]	
	I	II	III	IV	V	VI	VII	VIII	Maximum	Minimum
CORPS STUDY										
Water temperature (°C)	--	22 / 1-30	19 / 1-30	18 / 0-28	18 / 0-27	20 / 1-31	19 / 3-29	18 / 1-33	32	--
Dissolved oxygen (mg/l)	--	6.9 / 1.7-13.9	9.0 / 2.7-14.8	8.6 / 4.7-15.0+	6.4 / 0.2-14.5	8.7 / 3.2-15.0+	6.4 / 3.6-13.1	8.5 / 5.1-13.0	--	5.0
pH (pH units)	--	7.8 / 7.3-8.6	8.1 / 7.5-8.6	7.9 / 7.4-8.6	6.8 / 7.1-9.0	8.1 / 7.4-8.9	7.8 / 7.4-8.7	7.9 / 7.5-8.6	8.5	6.5
Carbon dioxide (mg/l)	--	3.9 / 0.0-7.6	1.7 / 0.0-7.9	3.3 / 0.0-7.9	5.4 / 0.0-16.5	2.6 / 0.0-8.5	6.1 / 0.0-8.5	3.9 / 0.0-9.0	12.0	--
Total alkalinity (mg/l)	--	129 / 64-205	124 / 35-187	151 / 76-233	157 / 70-227	141 / 62-249	140 / 70-247	164 / 76-261	--	20
Fecal coliform (cts/100ml) (1,000)	--	3.7 / 1-5.7	6.7 / .198-31	19.3 / 1-89	857.6 / 1.8-4,250	5.3 / .01-18	74.6 / .79-290	1.6 / 1.5-2.1	2	--
Total coliform (cts/100ml) (1,000)	--	77 / 30- 300	120 / 30- 300	120 / 28- 300	165 / 30- 300	71 / 14- 300	101 / 46- 300	71 / .8- 300	10	--

TABLE A-2 (Continued)
MALINE CREEK
WATER QUALITY AND SEDIMENT MEASUREMENTS FROM MALINE CREEK

Study[1]/Parameter[2]	Sampling Site I	II	III	IV	V	VI	VII	VIII	Standard[3] Maximum	Standard[3] Minimum
Chloride (mg/l)	--	66 / 17-196	68 / 10-204	83 / 30-278	75 / 25-272	105 / 15-240	43 / 10-128	139 / 37-420	250	--
Turbidity (JTU)	--	93 / 1-750	60 / 5-400	60 / 5-320	39 / 2-230	101 / 2-460	87 / 1-500	92 / 5-460	--	--
Chemical oxygen demand	--	14 / 6-21	16 / 6-30	15 / 7-23	24 / 5-62	13 / 4-27	18 / 10-28	12 / 5-19	20	--
Calcium hardness (mg/l)	--	144 / 75-200	147 / 65-225	184 / 125-255	204 / 155-260	170 / 5-260	156 / 75-290	187 / 110-270	--	--
Total hardness (mg/l)	--	211 / 102-386	212 / 65-370	250 / 110-420	268 / 102-390	239 / 99-408	212 / 100-402	287 / 135-424	--	150
Specific conductance (umhos/cm)	--	697 / 325-1300	744 / 450-1225	852 / 345-1600	869 / 314-1600	781 / 298-1250	559 / 250-1000	959 / 480-1800	1500	--
Nitrite and nitrate (mg/l)	--	0.58 / 0.00-2.00	0.69 / 0.05-1.90	0.69 / 0.05-2.20	0.76 / 0.05-2.0	0.64 / 0.05-1.70	0.66 / 0.05-1.90	0.86 / 0.00-3.60	1.1	--

TABLE A-2 (Continued)
MALINE CREEK
WATER QUALITY AND SEDIMENT MEASUREMENTS FROM MALINE CREEK

Study[1]/Parameter[2]	Sampling Site								Standard[3]	
	I	II	III	IV	V	VI	VII	VIII	Maximum	Minimum
Ortho phosphate (mg/l)	--	0.51 / 0.11-1.34	0.43 / 0.04-1.00	0.28 / 0.10-0.40	1.84 / 0.08-7.70	0.25 / 0.08-0.72	0.36 / 0.01-2.10	0.26 / 0.09-0.40	0.20	--
Total phosphate (mg/l)	--	0.51 / 0.14-1.76	0.70 / 0.04-1.30	0.58 / 0.13-4.90	1.53 / 0.08-12.6	0.28 / 0.09-1.00	0.62 / 0.11-2.80	0.28 / 0.11-0.40	0.50	--
Sulfate (mg/l)	--	95 / 35-185	123 / 30-188	129 / 35-200	129 / 33-215	89 / 20-168	67 / 15-140	102 / 40-188	250	--
Iron (mg/l)	--	3.39 / 0.02-14.0	1.46 / 0.10-8.80	1.63 / 0.02-9.1	1.59 / 0.30-8.5	2.81 / 0.10-17.0	3.71 / 0.02-12.40	2.53 / 0.02-12.0	1.0	--
CORPS-EPA: Water Quality										
Dissolved oxygen (mg/l)	4.8 / 2.9-6.0	3.8 / 1.8-6.7	5.1 / 4.3-6.7	4.8 / 4.0-5.5	4.8 / 3.1-6.2	6.0 / 4.4-8.3	--	--	--	5.0
pH (pH units)	11.6 / 10.4-12.0	7.3 / 6.9-7.5	7.6 / 7.5-7.6	7.6 / 7.3-7.8	7.7 / 7.4-8.0	7.3 / 6.9-7.7	--	--	8.5	6.5

TABLE A-2 (Continued)
MALINE CREEK
WATER QUALITY AND SEDIMENT MEASUREMENTS FROM MALINE CREEK

Study[1]/Parameter[2]	Sampling Site								Standard[3]	
	I	II	III	IV	V	VI	VII	VIII	Maximum	Minimum
Total alkalinity (mg/l)	505 128-670	139 80-165	118 82-135	167 81-200	171 75-289	164 76-263	--	--	--	20
Fecal coliform (cts/100 ml) (1,000)	.1 .002-0.54	5.6 2.4-13.0	14 1.7-40.0	9.7 0.04-33.0	6.9 0.170-26.0	2 0.33-5.3	--	--	2,000	--
Total coliform (cts/100 ml) (1,000)	.5 0.002-2.1	143 2.2-560	182 130-660	17 0.7-50	115 1.1-450	156 1.1-420	--	--	10,000	--
Fecal streptococci (cts/100 ml) (1,000)	8.5 .002-34.0	18 0.87-59.0	20.3 1.0-76.0	20.6 0.42-79	14.1 0.2-55	17.2 0.53-42	--	--	2,000	--
Biological oxygen demand (mg/l)	15 9-26	23 15-31	21 10-48	51 11-138	12 3-36	30 14-68	--	--	10	--
Specific conductance (umhos/cm)	4110 1040-5600	670 330-860	645 370-780	745 320-940	730 280-929	595 290-960	--	--	1,500	--
Nitrite and Nitrate (mg/l)	0.61 0.35-0.72	0.11 0.03-0.29	0.27 0.18-0.39	0.07 0.00-0.16	0.07 0.02-0.18	0.27 0.00-0.76	--	--	1.10	--

TABLE A-2 (Continued)
MALINE CREEK
WATER QUALITY AND SEDIMENT MEASUREMENTS FROM MALINE CREEK

Study[1]/Parameter[2]	Sampling Site								Standard[3]	
	I	II	III	IV	V	VI	VII	VIII	Maximum	Minimum
Ammonia nitrogen (mg/l)	0.32 0.09-0.49	0.04 0.04-0.06	0.03 0.02-0.05	0.06 0.02-0.14	0.05 0.02-0.10	0.13 0.00-0.44	--	--	0.1	--
Organic nitrogen (mg/l)	1.59 1.10-2.30	1.43 0.98-1.60	0.91 0.71-1.11	0.92 0.53-1.24	0.69 0.57-0.99	1.64 0.93-2.70	--	--	--	--
Ortho phosphate (mg/l)	0.07 0.01-0.23	0.64 0.33-0.79	0.39 0.33-0.44	0.32 0.28-0.43	0.25 0.17-0.47	0.28 0.21-0.34	--	--	0.20	--
Total phosphate (mg/l)	0.18 0.07-0.52	0.93 0.52-1.12	0.53 0.46-0.65	0.47 0.30-0.63	0.36 0.27-0.64	0.50 0.27-0.67	--	--	0.50	0
Total organic carbon (mg/l)	26 21-35	31 23-34	30 21-48	15 7-23	24 13-45	44 25-92	--	--	--	--
Iron (ug/l)	1142 70-43000	--	--	--	--	2500	--	--	1,000	--
Chronium (ug/l)	52 0-80	--	--	--	0	--	--	--	100	--
Zinc (ug/l)	27 0-62	--	--	--	76	--	--	--	1,000	--

TABLE A-2 (Continued)
MALINE CREEK
WATER QUALITY AND SEDIMENT MEASUREMENTS FROM MALINE CREEK

Study[1]/Parameter[2]	Sampling Site								Standard[3]	
	I	II	III	IV	V	VI	VII	VIII	Maximum	Minimum
Copper (ug/l)	22 / 15-34	--	--	--	19	--	--	--	1,000	--
Manganese (ug/l)	150 / 26-500	--	--	--	890	--	--	--	100	--
Lead (ug/l)	300 / 280-340	--	--	--	240 / 170	--	--	--	1,000	--
Cadmium (ug/l)	11 / 0-16	--	--	--	0	--	--	--	12	--
Total solids (mg/l)	47 / 10-151	35 / 11-100	41 / 13-84	123 / 7-400	24 / 12-42	36 / 11-118	--	--	--	--
Volatile solids (mg/l)	8 / 2-22	12 / 6-21	12 / 5-22	91 / 2-340	6 / 3-14	19 / 5-50	--	--	--	--

TABLE A-2 (Continued)
MALINE CREEK
WATER QUALITY AND SEDIMENT MEASUREMENTS FROM MALINE CREEK

Study[1]/Parameter[2]	Sampling Site								Standard[3]	
	I	II	III	IV	V	VI	VII	VIII	Maximum	Minimum
CORPS-EPA: Sediments										
Chemical oxygen demand (mg/kg)	32,000	26,000	20,000	110,000	14,000	28,000	--	--	--	--
Biological oxygen demand (mg/kg)	3,200	3,500	2,200	13,000	1,500	1,800	--	--	--	--
Organic nitrogen (mg/kg)	900	500	600	1,800	400	100	--	--	--	--
Total organic carbon (%)	8.22	6.68	5.14	28.30	3.60	7.20	--	--	--	--
CORPS-SIU: Water Quality										
Dissolved oxygen (mg/l)	7.39 7.03-7.75	6.70 6.40-7.00	7.28 5.95-8.60	7.02 6.40-7.63	4.81 6.05-3.57	6.10 5.80-6.40	--	--	--	5.0
pH (pH units)	9.8 10.2-9.4	7.8 8.2-7.4	7.7 8.1-7.3	7.8 8.1-7.4	7.6 8.0-7.2	7.7 8.1-7.3	--	--	8.5	6.5
Total alkalinity (mg/l)	68 40-96	110 184-136	156 160-152	164 192-136	166 184-148	151 184-118	--	--	--	20
Fecal coliform (cts/100 ml)	65 20-110	400 1-800	1920 1960-1880	615 90-1140	555 250-860	1240 260-2220	--	--	2,000	--

TABLE A-2 (Continued)
MALINE CREEK
WATER QUALITY AND SEDIMENT MEASUREMENTS FROM MALINE CREEK

Study[1]/Parameter[2]	Sampling Site								Standard[3]	
	I	II	III	IV	V	VI	VII	VIII	Maximum	Minimum
Total coliform (cts/100 ml) (1,000)	1.69 / .08-3.3	32.605 / .41-64.8	132.5 / 69-196	86.215 / 43-172	43.350 / 44.7-42	24.85 / 10.7-39	--	--	10,000	--
Fecal streptococci (cts/100 ml) (1,000)	.64 / .22-1.06	.66 / .04-1.28	2.38 / 1.3-3.46	.53 / .11-.95	.34 / .08-0.6	0.315 / 0.04-0.59	--	--	2,000	--
Chloride (mg/l)	97 / 90-104	128 / 95-160	124 / 173-76	98 / 113-82	72 / 80-64	542 / 83-1000	--	--	[illegible]	--
Turbidity (FTU)	16.4 / 3.9-29.0	15.3 / 3.6-27.0	8.5 / 5.0-12.0	9.6 / 3.3-16.0	3.6 / 2.5-4.7	27.8 / 3.5-52.0	--	--	--	--
Chemical oxygen demand (mg/l)	13 / 5-21	12 / 5-20	20 / 5-35	24 / 5-44	30 / 5-55	25 / 5-45	--	--	20	--
Calcium hardness (mg/l)	122 / 84-160	189 / 250-728	172 / 200-144	178 / 220-136	204 / [illegible]-148	[illegible] / [illegible]	--	--	--	--
Total hardness (mg/l)	164 / 100-228	224 / 260-188	230 / 252-208	252 / 300-204	310 / 380-240	237 / 313-[illegible]	--	--	--	150
Specific conductance (umhos/cm)	688 / 725-650	812 / 900-725	688 / 825-550	790 / 1020-560	775 / 975-575	1462 / 1175-17[illegible]	--	--	1,500	--
Nitrite (ug/l)	60 / 19-100	28 / 9-48	43 / 9-77	60 / 6-114	67 / 14-120	20 / [illegible]-30	--	--	1,000	--

TABLE A-2 (Continued)
MALINE CREEK
WATER QUALITY AND SEDIMENT MEASUREMENTS FROM MALINE CREEK

Study[1]/Parameter[2]	Sampling Site I	II	III	IV	V	VI	VII	VIII	Standard[3] Maximum	Minimum
Nitrate (mg/l)	4.63 / 0.45-8.80	3.35 / 0.29-6.40	4.72 / 0.23-9.20	3.88 / 0.16-7.60	3.25 / 0.10-6.40	5.05 / 0.09-10.00	--	--	10.0	--
Ammonia nitrogen (mg/l)	0.66 / 0.38-0.94	0.44 / 0.37-0.50	1.14 / 0.33-1.95	1.04 / 0.19-1.89	2.01 / 0.52-3.50	0.42 / 0.16-0.67	--	--	0.1	--
Total phosphate (mg/l)	0.80 / 0.62-0.97	1.28 / 1.25-1.31	3.30 / 1.30-5.30	1.81 / 0.96-2.65	2.67 / 3.05-2.28	1.35 / 1.00-1.69	--	--	0.50	--
Iron (mg/l)	0.13 / 0.04-0.22	0.54 / 0.15-0.93	0.67 / 0.36-0.97	0.29 / 0.23-0.35	0.11 / 0.21-0.01	0.31 / 0.09-0.52	--	--	1.0	--
Zinc (mg/l)	0.46 / 0.47-0.45	0.32 / 0.33-0.30	0.20 / 0.17-0.22	0.10 / 0.11-0.09	0.06 / 0.06-0.05	0.06 / 0.07-0.05	--	--	1.0	--
Copper (ug/l)	0.03 / 0.00-0.05	0.03 / 0.00-0.05	0.03 / 0.00-0.06	0.03 / 0.00-0.05	0.02 / 0.00-0.03	0.03 / 0.00-0.06	--	--	1.0	--

TABLE A-2 (Continued)
MALINE CREEK
WATER QUALITY AND SEDIMENT MEASUREMENTS FROM MALINE CREEK

Study[1]/Parameter[2]	Sampling Site								Standard[3]	
	I	II	III	IV	V	VI	VII	VIII	Maximum	Minimum
Magnesium (mg/l)	10.07 / 3.84-16.30	8.40 / 2.40-14.40	13.94 / 12.48-15.40	24.95 / 33.60-16.30	25.45 / 28.80-22.10	21.36 / 28.32-14.40	--	--	--	--
Lead (ug/l)	13 / 20-6	14 / 23-6	16 / 28-5	18 / 28-7	19 / 30-8	18 / 27-10	--	--	--	--
Mercury (ug/l)	Less than 7 ug at all sites									
Cyanide	Below detection limits at all sites									
Chlorinated hydrocarbons (ug/l)	Less than 0.02 ug/l at all sites									
Phenola	Below detection limits at all sites									

TABLE A-2 (Continued)
MALINE CREEK
WATER QUALITY AND SEDIMENT MEASUREMENTS FROM MALINE CREEK

Study[1]/Parameter[2]	Sampling Site								Standard[3]	
	I	II	III	IV	V	VI	VII	VIII	Maximum	Minimum
Suspended solids (mg/l)	246 / 326-167	274 / 356-193	267 / 342-192	270 / 370-169	266 / 360-172	249 / 314-184	--	--	--	--

[1]Study sources: (1) U.S. Army Corps of Engineers (1972).

(2) CORPS-EPA - Environmental Protection Agency (1972).

(3) CORPS-SIU - Office of Research and Projects (1976).

[2]Parameter values given are arranged in the following order:

(1) CORPS and CORPS-EPA studies - $\frac{\text{Average}}{\text{Minimum-Maximum}}$

(2) CORPS-SIU study - $\frac{\text{Average}}{\text{Low flow - High flow}}$

[3]Standard values have been established by referring to the following references:

(1) Missouri Clean Water Commission. 1973. Water Quality Standards
(2) U.S. Environmental Protection Agency. 1973. Proposed Criteria for Water Quality
(3) U.S. Army Corps of Engineers. Undated. Unpublished records of water quality measurements for various St. Louis District projects, which demonstrate average values expected for area streams.

33. Future trends in water quality for Maline Creek are dependant upon the success of the Environmental Protection Agency implementation and enforcement of the various existing and future clean water public laws.

Climate and Weather

34. The St. Louis area experiences a somewhat modified continental climate because of its latitudinal and interior location. Moreover, the St. Louis area is in a transitional zone between the Humid Subtropical climate and the Humid Continental with a long summer climate. The region has four distinct seasons normally without prolonged periods of extreme cold, extreme heat, or high humidity. As is typical of continental climates, the area experiences wide day-to-day and seasonal fluctuations in weather and considerable departures from temperatures and precipitation averages. Three major air masses influence the climate of the St. Louis area. These are: a cold, dry Continental Polar air mass originating in the Canadian prairie provinces; a warm, humid Maritime Tropical air mass developed in the North Atlantic high pressure systems; and a cool, moist Maritime Polar air mass originating in the northeastern Pacific Ocean. The latter drops its moisture over the mountain states and reaches St. Louis as a dry air mass. The Pacific Maritime Polar air mass influences the regional weather pattern by changing the location of the line of intersection between the Maritime Tropical and Continental Polar air masses. If the prevailing westerly winds are strong, the line of intersection is moved farther east than if they are weaker and exert less force on the latter two air masses. The Maritime Tropical air mass provides the area with its precipitation when it meets the denser, colder air from the Continental Polar mass, rises and cools. The St. Louis

area is close to the major tracks of cool season middle latitude storms which develop over the Great Plains and move northeastward across the midwestern states into the Great Lakes - St. Lawrence River Region. The influences of extra-tropical low pressure systems on the area are extensive. The presence intensity, and location of cyclonic activity is related to abrupt short-term variations in temperatures; the location, amount, and intensity of precipitation; patterns of cloudiness; the occurrence of thunderstorms, heat waves, and other severe weather disturbances. During some winter and spring seasons, cyclone development is active in Texas and Colorado. When this happens, the regional weather patterns are highly variable as the interplay of cold and warm air associated with these storms occurs in the vicinity of the St. Louis area.

35. The average yearly temperature is 55^{O}F. Cold polar air masses move through the area every winter and produce average minimum temperatures of 15^{O}F. These cold waves usually last 3 or 4 days, with moderate above-freezing weather returning to warm the air. In recent years, periods of 7 to 10 days with below normal temperatures have occurred during which ponds freeze to a thickness of 2 to 4 inches. The lowest temperature recorded for the St. Louis region was -23^{O}F in January of 1864. July and August are the hottest months. During these months, there are an average of 22 days with temperatures of above 90^{O}F. When warm, high pressure systems stagnate over the watershed, temperatures may exceed 100^{O}F for 3 to 5 days. The summer months generally show average daily temperature ranges of only 18^{O} to 20^{O}F. The maximum temperature recorded at St. Louis was 115^{O}F in July of 1954 (TABLE A-3). The average number of days below 32^{O}F or above 90^{O}F (temperature thresholds) is presented in TABLE A-4.

TABLE A-3
MALINE CREEK
TEMPERATURE

Month	Normal (1931-1960) Daily Max.	Daily Min.	Monthly	Extremes (1960-1972) Record High	Year	Record Low	Year
Jan	40.2	23.5	31.9	76	1970	-11	1963
Feb	44.0	25.3	34.7	85	1972	-2	1965
Mar	52.8	32.4	42.6	88	1963	5	1962
Apr	65.9	43.8	54.9	92	1970	22	1972
May	75.1	53.3	64.2	92	1972+	31	1966
Jun	85.1	63.1	74.1	98	1971	43	1969
Jul	89.2	66.9	78.1	106	1966	51	1972+
Aug	87.3	66.3	76.8	105	1962	47	1965
Sep	81.3	57.6	69.5	100	1971	40	1972+
Oct	70.1	46.6	58.4	94	1963	25	1972
Nov	53.7	34.5	44.1	81	1971	1	1964
Dec	43.0	26.5	34.8	76	1970	-6	1963
Year	65.6	45.0	55.3	106	Jul 1966	-11	Jan 1963

+Also occurred in earlier years.

Source: U.S. Department of Commerce, National Oceanic and Atmospheric Administration, Local Climatological Data, Annual Summary with Comparative Data, St. Louis, Missouri, 1972.

TABLE A-4
MALINE CREEK
TEMPERATURE THRESHOLDS

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Days Over 90 Degrees	0	0	0	0	1	6	12	10	4	0	0	0	33
Days Under 32 Degrees	26	23	16	3	0	0	0	0	0	2	13	23	106

36. The mean duration of the growing season (frost-free period) is 217 days and usually lasts from early April to the end of October. Occasionally, the first autumn freeze occurs as early as mid-October while the last spring freeze has been as late as the first week in May (see TABLE A-5). The average annual amount of precipitation is 35.4 inches as recorded by the gage at Lambert-St. Louis International Airport. If only the last 25 years through 1972 are considered, this average increases to 39.5 inches. Mean monthly precipitation is remarkably uniform. June is normally the wettest month, with a mean monthly precipitation of 3.92 inches. January is the driest month, with a mean monthly precipitation of 2.16 inches (see TABLE A-6). Long-time records show occasional monthly amounts of precipitation of over 10 inches during the summer. TABLE A-7 presents a summary of precipitation data within the St. Louis area. Thunderstorms produce significant amounts of the region's precipitation. Severe thunderstorms are usually of short duration but may result in flash flooding. Hail, which is often associated with squall line activity and lightning, causes damage. The majority of the hailstorms occur between 2:00 p.m. and 9:00 p.m., with a concentrated majority between the hours of 3:00 p.m. and 6:00 p.m. The average monthly and annual frequency of thunderstorm ocurrences within the St. Louis area is shown in TABLE A-8.

TABLE A-5
MALINE CREEK
LENGTH OF GROWING SEASON

Year	Date of Last Killing Frost in Spring	Date of First Killing Frost in Autumn	Last Killing Frost to Frost Killing Frost (days)	Latest Date with Temperature 32o or Lower in Spring	Earliest Date with Temperature 32o or Lower in Autumn
1873	Mar. 27	Oct. 23	210	-------	Oct. 23
1874	Apr. 29	-------	---	Apr. 29	Oct. 31
1875	May 2	Oct. 12	163	May 2	Oct. 31
1876	Mar. 30	Oct. 16	200	Mar. 30	Oct. 15
1877	Mar. 19	Nov. 3	229	Apr. 3	Nov. 5
1878	Feb. 27	Oct. 18	233	Feb. 26	Oct. 27
1879	Apr. 5	Nov. 1	210	Apr. 5	Oct. 31
1880	Mar. 2	Oct. 18	230	Apr. 7	Oct. 18
1881	Apr. 14	Nov. 3	203	Apr. 14	Nov. 15
1882	Mar. 11	Nov. 13	247	Apr. 12	Nov. 12
1883	May 22	Nov. 12	174	Apr. 2	Nov. 12
1884	Mar. 14	Oct. 23	223	Mar. 14	Nov. 5
1885	Apr. 4	Nov. 9	219	Apr. 8	Nov. 13
1886	Apr. 6	Oct. 28	205	Apr. 6	Nov. 12
1887	Mar. 28	Nov. 19	236	Apr. 5	Oct. 20
1888	Mar. 14	Nov. 11	242	Mar. 29	Nov. 12
1889	Apr. 6	Nov. 6	214	Apr. 6	Nov. 5
1890	Apr. 1	Oct. 27	209	Apr. 1	Oct. 31
1891	Apr. 7	Oct. 15	191	Apr. 7	Nov. 13
1892	Apr. 9	Oct. 25	199	Apr. 9	Oct. 25
1893	Apr. 21	Oct. 25	187	Mar. 27	Nov. 13
1894	Mar. 29	Oct. 14	199	Mar. 29	Nov. 6
1895	Mar. 21	Oct. 20	213	Mar. 21	Oct. 29
1896	Apr. 3	Oct. 21	201	Apr. 3	Nov. 8
1897	Mar. 25	Nov. 6	226	Mar. 27	Nov. 16
1898	Apr. 7	Oct. 27	203	Apr. 6	Oct. 31
1899	Apr. 5	Sep. 30	178	Apr. 4	Nov. 2
1900	Apr. 12	Nov. 9	211	Apr. 12	Nov. 8
1901	Apr. 1	Nov. 4	217	Mar. 21	Nov. 4
1902	Apr. 8	Nov. 28	234	Apr. 8	Nov. 26
1903	Mar. 29	Oct. 24	209	Apr. 3	Nov. 6
1904	Apr. 21	Oct. 26	188	Apr. 21	Nov. 12
1905	Apr. 16	Oct. 12	179	Apr. 16	Oct. 28
1906	Apr. 1	Oct. 11	193	Apr. 1	Oct. 31
1907	Apr. 17	Oct. 28	194	Apr. 17	Oct. 28
1908	Apr. 3	Nov. 5	216	Apr. 3	Nov. 5
1909	Apr. 10	Oct. 12	185	Apr. 10	Oct. 12
1910	Apr. 23	Oct. 28	188	Apr. 24	Oct. 28

TABLE A-5 (Continued)
MALINE CREEK
LENGTH OF GROWING SEASON

Year	Date of Last Killing Frost in Spring	Date of First Killing Frost in Autumn	Last Killing Frost to Frost Killing Frost (days)	Latest Date with Temperature 32° or Lower in Spring	Earliest Date with Temperature 32° or Lower in Autumn
1911	Apr. 7	Nov. 2	209	Apr. 7	Nov. 1
1912	Mar. 25	Nov. 2	222	Mar. 25	Nov. 2
1913	Mar. 28	Oct. 21	207	Mar. 28	Oct. 21
1914	Apr. 9	Oct. 27	201	Apr. 9	Oct. 27
1915	Apr. 3	Oct. 9	189	Apr. 3	Nov. 14
1916	Apr. 9	Oct. 21	195	Apr. 8	Oct. 20
1917	Apr. 9	Oct. 12	186	Apr. 9	Oct. 23
1918	Apr. 10	Nov. 1	205	Apr. 10	Nov. 23
1919	Mar. 9	Nov. 5	241	Apr. 1	Nov. 12
1920	Apr. 13	Oct. 29	199	Apr. 13	Nov. 11
1921	Apr. 17	Nov. 10	207	Apr. 17	Nov. 10
1922	Mar. 8	Nov. 16	253	Mar. 8	Nov. 24
1923	Apr. 8	Oct. 31	206	Apr. 8	Oct. 31
1924	Apr. 2	Nov. 8	220	Apr. 2	Nov. 8
1925	Mar. 16	Oct. 27	225	Mar. 16	Oct. 27
1926	Apr. 15	Nov. 2	201	Apr. 15	Nov. 2
1927	Mar. 21	Nov. 6	230	Mar. 21	Nov. 5
1928	Apr. 15	Nov. 20	219	Apr. 15	Nov. 20
1929	Mar. 10	Nov. 5	240	May 2	Nov. 20
1930	Mar. 28	Oct. 20	206	Mar. 28	Oct. 20
Average to 1930 (58 yrs)	Apr. 3	Oct. 29	209	Apr. 0	Nov. 5
1931-1960			Mean 217	Mean Apr. 3	Mean Nov. 6

Footnotes:

1. Data for the years 1873 to 1930, inclusive, were obtained from Weather Bureau publication "Climatic Summary of the United States," Section 55 - SOUTHEASTERN MISSOURI, p. 55-20.

2. Data for years 1931 to 1960 for which records are available was obtained from the Weather Bureau publication, "Climate of the States," Missouri, June 1969.

Source: St. Louis County Weather Bureau, Missouri

TABLE A-6
MALINE CREEK
MONTHLY PRECIPITATION

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
1837	0.70	1.08	3.43	1.40	3.13	2.77	4.07	3.10	2.88	1.15	1.60	1.70	27.01
1838	3.72	1.25	1.51	3.36	4.68	3.73	3.13	4.48	0.06	3.06	2.09	0.44	31.51
1839	2.21	2.50	2.59	5.46	7.93	7.26	5.71	2.89	2.45	3.96	2.48	2.00	47.44
1840	1.80	1.38	2.10	3.31	4.58	6.27	2.36	7.15	3.96	6.30	1.73	0.71	41.65
1841	0.84	0.88	4.99	3.85	2.38	1.67	3.09	5.63	3.22	6.81	5.44	3.93	42.73
1842	0.45	3.90	2.22	3.49	3.22	5.12	1.76	2.64	2.17	2.57	2.38	2.39	32.31
1843	2.34	1.90	3.49	4.87	4.15	3.95	2.49	1.32	2.19	1.55	4.82	1.72	34.79
1844	3.36	1.73	4.84	3.86	11.26	6.85	8.13	0.45	0.30	2.25	1.17	1.61	45.81
1845	1.83	1.07	3.18	2.28	4.42	10.01	4.75	6.23	1.03	1.16	1.10	0.93	37.99
1846	2.98	1.27	1.27	4.84	3.75	5.21	0.84	4.73	4.84	2.71	2.11	10.90	45.45
1847	2.12	3.58	2.28	3.98	4.36	8.61	5.37	0.90	3.26	8.74	8.63	0.89	52.72
1848	1.86	2.27	6.61	3.16	8.10	17.07	5.37	9.74	1.12	2.41	1.91	5.74	65.36
1849	4.18	0.56	2.70	2.64	2.71	6.46	9.40	5.15	5.81	2.17	2.11	1.82	45.71
1850	1.94	4.10	5.63	7.68	7.47	1.47	4.83	2.10	3.74	2.71	6.24	2.59	50.50
1851	0.61	6.74	3.14	4.70	2.83	6.19	5.77	8.97	0.49	1.51	1.99	3.90	46.84
1852	0.99	2.12	7.67	2.28	5.19	10.25	3.36	1.60	1.47	5.26	3.29	3.48	46.96
1853	0.52	1.67	0.79	3.24	3.64	3.23	4.10	5.48	4.67	0.96	1.51	1.08	30.89
1854	1.18	3.11	7.49	7.60	6.30	3.21	0.92	1.80	1.44	4.15	1.94	1.49	40.63
1855	4.66	0.70	2.89	2.65	7.46	4.27	5.17	6.53	3.89	3.89	5.16	3.10	50.37
1856	1.03	3.64	1.06	6.35	3.03	1.24	4.61	6.82	3.51	2.10	4.90	4.29	42.58
1857	0.41	7.74	1.80	1.72	4.81	3.71	2.82	4.15	3.18	3.02	3.80	1.87	39.03
1858	3.42	2.12	3.96	6.07	10.64	6.69	8.03	2.87	3.86	7.73	4.92	8.52	68.83
1859	2.32	5.35	7.32	4.89	6.60	11.02	5.54	2.93	4.44	1.80	5.43	3.76	61.40

TABLE A-6 (Continued)
MALINE CREEK
MONTHLY PRECIPITATION

Year	Jan.	Feb.	Mar.	Ap.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
	Month												
1860	1.80	2.60	1.16	2.03	2.29	6.58	2.97	2.36	2.11	1.58	1.63	2.0[illegible]	29.79
1861	1.16	2.01	7.38	3.18	4.39	4.96	2.04	3.44	4.14	2.85	1.39	1.09	38.03
1862	4.01	0.80	4.11	4.82	2.51	2.85	3.61	1.32	6.27	3.73	3.59	6.39	44.00
1863	4.11	3.99	3.02	1.55	2.68	3.16	2.51	6.93	1.56	4.76	2.15	4.03	40.45
1864	2.74	0.82	1.71	5.58	3.90	0.41	3.60	4.91	2.82	3.15	5.25	2.72	37.61
1865	0.87	3.75	8.61	3.31	5.66	5.21	7.94	1.96	2.60	3.33	0.00	3.53	46.87
1866	4.16	2.24	2.80	1.56	2.24	5.59	3.67	5.16	10.53	2.01	1.37	1.87	47.2[illegible]
1867	2.28	4.81	2.37	0.53	8.26	5.64	3.71	2.29	0.17	1.31	2.74	3.[illegible]	37.7[illegible]
1868	1.71	0.55	7.66	7.08	3.96	1.58	2.03	8.53	5.25	2.11	2.04	3.09	[illegible]5.59
1869	2.02	2.49	4.24	4.61	3.60	6.25	2.49	5.51	1.70	3.42	7.48	3.16	46.97
1870	2.25	0.28	2.76	2.39	2.05	1.46	1.81	6.05	1.07	3.40	1.87	1.69	27.08
1871	2.53	2.92	1.27	0.49	3.15	2.51	1.64	3.55	0.25	2.07	1.83	1.17	23.[illegible]
1872	0.64	1.15	2.43	2.77	6.04	4.28	4.59	0.93	3.38	0.55	2.01	1.70	30.4[illegible]
1873	3.53	1.52	2.10	6.88	5.73	6.68	5.96	0.07	3.02	3.27	1.64	5.10	45.5[illegible]
1874	3.14	3.66	4.36	3.44	3.70	2.00	5.71	4.70	2.30	1.09	2.32	1.4[illegible]	37.8[illegible]
1875	0.54	2.59	4.08	2.53	5.48	10.84	9.50	2.66	0.24	1.23	0.89	2.42	43.00
1876	4.75	2.86	6.90	2.25	3.13	6.43	5.90	5.03	7.63	1.66	1.74	0.18	48.46
1877	1.24	0.88	3.41	3.03	3.11	8.69	2.88	2.61	3.56	4.92	3.76	3.34	41.43
1878	2.36	1.69	2.79	6.74	4.63	2.40	3.92	4.75	3.42	3.27	1.38	3.48	40.83
1879	1.64	1.48	1.92	2.31	0.95	4.04	1.97	2.23	1.34	0.68	4.30	2.84	25.70
1880	3.83	2.65	2.51	3.31	3.44	2.56	5.17	1.53	3.10	2.09	2.67	1.80	34.66
1881	0.49	4.16	1.95	3.14	3.96	2.74	2.13	0.31	3.14	7.21	6.74	1.40	37.37

TABLE A-6 (Continued)
MALINE CREEK
MONTHLY PRECIPITATION

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
1882	2.80	8.94	3.49	3.58	4.55	4.53	3.84	2.20	1.73	2.44	3.24	1.81	43.15
1883	0.94	5.88	2.29	3.31	2.89	5.04	4.31	3.34	0.01	6.60	3.71	1.78	40.10
1884	0.79	4.43	3.00	4.15	2.68	4.52	2.86	1.21	6.04	2.48	2.30	6.18	40.64
1885	3.26	0.87	0.40	4.84	2.80	7.68	2.58	2.96	8.98	7.51	1.68	2.03	45.59
1886	3.11	1.71	3.04	2.10	7.84	7.09	0.55	2.44	9.60	0.85	3.36	2.65	44.34
1887	0.65	3.68	3.54	4.36	5.27	2.54	2.74	1.14	2.47	0.76	4.61	3.54	35.30
1888	2.15	2.39	3.79	1.88	3.81	8.09	2.09	6.66	1.31	2.59	4.40	2.01	41.17
1889	3.04	4.78	1.62	1.68	3.80	4.72	2.02	0.85	3.54	1.65	4.43	1.03	33.16
1890	7.47	2.86	5.99	4.05	5.81	3.18	0.37	2.43	1.80	0.86	1.55	1.32	37.69
891	1.35	2.95	2.29	2.29	2.73	5.97	1.50	2.75	1.43	0.65	5.30	1.32	30.53
1892	1.52	4.89	1.92	7.60	7.87	2.73	4.64	1.75	1.59	1.66	3.46	1.99	41.62
1893	0.33	2.98	5.10	10.84	5.42	3.49	2.49	0.65	3.69	1.66	1.36	1.32	39.33
1894	2.56	2.88	2.69	2.68	3.61	1.12	1.35	1.66	3.11	1.56	1.49	2.73	27.44
1895	1.65	0.43	2.82	0.46	3.16	2.46	7.26	2.08	2.01	0.23	3.98	4.66	31.20
1896	1.43	2.81	2.03	2.43	9.12	4.57	4.67	2.12	2.42	1.20	3.70	1.05	37.55
1897	3.75	2.67	8.25	4.66	1.59	5.32	3.23	0.66	0.09	0.31	6.21	3.43	40.17
1898	4.53	1.71	7.73	3.85	8.55	3.85	7.44	0.87	3.23	4.34	2.07	1.03	49.20
1899	1.66	3.40	3.96	1.98	6.32	2.32	4.54	2.77	1.27	2.89	1.95	1.55	34.61
1900	0.65	5.09	1.45	1.83	4.47	2.62	3.85	1.30	2.68	2.07	3.10	0.40	29.51
1901	1.12	1.86	2.94	2.35	2.69	3.92	1.47	0.76	0.64	2.12	1.21	3.72	24.80
1902	1.18	0.83	4.50	2.49	3.04	7.86	2.34	5.20	1.98	2.00	3.20	3.81	38.43
1903	1.76	3.14	3.20	2.79	2.08	5.71	2.68	6.16	3.06	1.37	0.61	1.25	33.81
1904	3.15	0.84	7.87	3.25	2.88	4.64	3.09	2.62	2.97	0.50	0.54	1.36	33.71

TABLE A-6 (Continued)
MALINE CREEK
MONTHLY PRECIPITATION

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
1905	2.47	1.12	2.35	2.32	4.67	2.72	4.42	2.58	5.56	6.64	1.63	2.06	38.54
1906	3.57	2.92	4.53	1.98	2.61	2.80	0.98	3.72	4.40	1.25	4.67	2.09	35.52
1907	7.35	1.12	2.39	3.65	5.57	4.96	3.32	4.36	1.57	3.15	1.89	2.06	41.39
1908	2.08	3.39	3.43	3.84	7.72	3.02	4.24	1.55	1.24	0.21	2.83	0.64	34.19
1909	3.20	3.94	3.69	6.18	5.99	2.63	7.34	0.66	4.22	3.40	4.36	1.89	47.50
1910	2.73	3.22	0.14	4.09	5.23	4.24	4.21	1.90	6.09	3.98	0.30	1.18	37.31
1911	0.85	3.02	2.22	7.46	2.26	1.34	0.64	3.51	7.09	2.63	3.44	1.67	36.13
1912	1.31	2.80	5.85	7.84	4.29	6.93	5.29	2.65	2.84	2.61	1.76	0.42	44.59
1913	4.34	1.20	7.97	3.57	1.53	1.55	3.61	1.59	4.50	4.08	3.12	1.62	38.68
1914	2.21	4.63	1.25	1.92	0.69	0.10	1.52	5.42	6.68	7.45	1.53	2.23	35.63
1915	2.83	2.30	0.44	1.20	7.67	9.77	6.02	11.43	1.41	0.90	1.97	3.34	49.28
1916	8.53	1.78	1.83	1.78	3.00	3.97	1.20	10.69	2.69	1.64	2.53	2.16	41.80
1917	1.72	0.35	1.80	4.64	3.78	0.62	3.17	1.99	3.50	1.87	0.78	0.78	25.00
1918	1.31	2.09	0.67	7.09	3.28	1.47	0.60	5.26	5.09	3.63	2.73	2.69	35.91
1919	0.13	1.54	1.72	1.76	7.86	5.30	1.50	3.03	6.13	8.52	2.08	1.22	40.79
1920	1.85	0.74	3.97	3.43	5.00	1.53	0.73	4.16	4.79	2.36	0.56	2.41	31.53
1921	1.10	1.08	6.14	7.01	4.29	2.31	2.05	2.75	5.60	1.45	4.43	2.89	41.10
1922	0.74	1.52	4.84	7.40	1.26	0.80	2.42	1.79	2.49	1.74	2.36	4.98	32.34
1923	2.08	1.50	4.26	3.20	5.85	4.33	1.83	6.19	3.51	3.74	1.90	3.30	41.59
1924	1.15	1.29	3.24	1.90	6.18	6.80	3.62	3.90	1.97	0.30	1.53	4.63	36.51
1925	0.53	2.19	1.50	2.70	1.48	4.84	1.78	2.75	4.59	4.32	4.09	1.46	32.23
1926	1.69	2.52	3.95	4.42	1.58	1.72	0.54	1.83	7.40	3.84	2.71	1.15	33.35

TABLE A-6 (Continued)
MALINE CREEK
MONTHLY PRECIPITATION

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
1927	3.66	0.56	7.67	6.30	9.21	2.59	2.79	2.60	2.93	4.65	5.56	2.31	50.83
1928	1.91	2.43	2.27	3.02	2.18	7.25	6.66	4.83	1.70	2.24	1.90	2.22	38.61
1929	2.11	0.88	5.33	6.99	10.09	3.65	2.67	3.40	1.71	4.99	1.41	3.07	46.30
1930	5.70	2.35	0.99	1.32	1.69	2.63	0.25	0.28	3.51	1.84	1.77	0.90	23.32
1931	0.40	1.77	2.39	3.23	3.61	1.98	4.06	3.46	5.66	2.90	4.65	3.28	37.39
1932	2.50	1.59	1.33	3.19	2.09	2.45	5.30	8.68	2.15	4.28	2.08	2.37	38.01
1933	2.18	0.96	4.91	3.84	8.59	0.15	4.63	0.60	2.60	2.97	1.64	1.70	34.77
1934	1.72	1.26	2.96	2.40	0.54	3.25	1.22	3.14	5.86	2.23	2.66	1.95	29.19
1935	2.76	1.27	6.43	2.50	7.35	4.37	3.13	1.82	3.35	2.56	2.71	1.11	39.36
1936	1.32	1.97	1.67	2.80	0.85	3.07	0.60	0.85	5.94	2.79	2.20	2.08	26.14
1937	5.21	1.52	1.75	6.03	2.65	5.84	0.67	1.57	2.02	3.51	1.19	3.91	35.87
1938	1.31	3.51	9.52	3.34	5.97	4.50	3.64	1.15	1.01	1.17	4.04	2.06	41.22
1939	4.08	3.22	3.35	5.85	2.64	3.24	2.07	10.06	1.01	0.77	2.43	1.43	40.15
1940	1.33	1.39	1.50	3.86	1.46	2.66	0.78	4.11	0.03	1.44	3.23	3.21	25.00
1941	2.38	0.64	0.60	4.47	1.91	2.52	1.68	2.63	3.58	7.46	3.05	1.20	32.12
1942	1.44	2.54	1.92	2.19	4.99	7.24	7.92	3.60	1.99	2.30	4.40	4.61	45.14
1943	0.74	1.13	3.19	1.87	10.20	5.87	1.31	1.85	2.40	2.22	0.97	1.85	33.60
1944	0.30	2.72	2.49	8.82	4.15	1.34	3.45	2.46	4.37	0.78	1.11	1.52	33.51
1945	1.02	3.57	8.27	5.40	4.31	7.42	1.00	4.38	10.01	1.08	1.68	1.68	49.82
1946	1.59	3.11	3.08	2.85	5.58	3.46	1.45	20.45	1.52	3.45	7.63	2.95	57.12
1947	2.23	0.41	2.24	6.18	2.43	7.39	0.68	1.55	2.64	6.60	2.43	2.34	37.12
1948	0.94	1.54	5.31	2.21	3.17	3.98	7.30	0.84	2.50	2.25	2.46	2.01	34.51
1949	7.46	2.60	2.54	0.82	2.77	2.35	10.60	1.86	4.77	6.47	0.25	3.81	46.30

TABLE A-6 (Continued)
MALINE CREEK
MONTHLY PRECIPITATION

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
1950	8.12	3.31	3.52	4.07	3.90	3.89	1.32	7.73	2.67	0.79	3.10	0.79	43.21
1951	2.21	5.89	2.54	1.93	1.87	6.23	3.38	2.44	3.66	2.73	3.33	2.44	38.65
1952	1.21	2.20	3.76	3.68	1.49	2.30	3.15	2.95	0.97	0.39	2.71	1.89	26.70
1953	1.88	1.69	4.13	3.49	3.37	2.12	0.72	0.84	0.55	2.89	0.84	0.46	22.98
1954	1.51	0.62	1.10	3.00	2.80	2.75	2.14	3.93	4.75	3.76	1.37	2.27	30.00
1955	1.52	3.16	2.24	2.81	1.99	2.70	5.69	2.12	4.04	4.27	2.34	0.08	32.96
1956	0.73	3.51	1.36	2.98	4.68	2.39	7.66	2.10	1.17	0.64	2.53	3.91	33.66
1957	1.08	4.49	2.66	7.25	8.67	14.10	2.59	2.48	0.80	2.79	2.93	2.88	52.72
1958	2.18	0.58	4.14	2.80	3.07	3.61	7.91	3.24	4.01	1.46	4.07	0.19	37.26
1959	2.08	2.75	2.27	1.24	4.65	0.31	1.28	3.84	2.29	2.85	4.46	2.79	30.81
1960	1.42	1.28	2.59	2.26	3.71	3.99	1.98	1.89	1.38	3.32	2.12	2.24	28.18
1961	0.57	2.65	5.10	2.81	11.02	4.79	5.58	1.68	3.65	2.27	2.45	2.15	44.72
1962	4.32	2.64	3.60	4.83	1.89	7.42	3.98	2.65	3.19	2.73	0.92	2.24	40.41
1963	0.72	0.22	6.24	2.49	4.27	2.66	2.13	2.39	1.47	2.22	2.86	0.57	28.24
1964	1.89	2.46	3.77	3.79	2.63	1.82	3.10	2.54	1.79	0.84	2.70	1.52	28.85
1965	2.52	1.69	1.92	4.67	1.70	4.40	2.27	3.52	4.42	1.37	0.93	3.54	32.95
1966	0.83	3.20	0.61	5.47	2.88	0.48	2.91	2.73	2.52	1.68	4.60	2.31	30.22
1967	2.38	1.61	2.90	3.48	4.50	2.95	3.06	0.93	3.13	3.58	2.08	8.05	41.30
1968	--	--	--	--	--	--	--	4.82	2.92	1.30	5.45	3.24	---
1969	4.24	1.98	1.86	4.14	1.65	6.53	6.31	0.18	4.96	4.49	0.85	2.02	39.21

TABLE A-6 (Continued)
MALINE CREEK
MONTHLY PRECIPITATION

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
1970	0.29	0.63	2.32	7.12	3.32	4.93	0.94	7.59	5.30	2.32	0.79	1.42	36.97
1971	0.90	3.96	1.93	--	4.72	2.12	2.82	0.45	3.26	1.22	1.52	--	---
1972	0.60	1.35	2.79	6.49	1.21	2.76	3.48	5.25	4.35	0.97	--	--	---
Normal	2.16	2.21	3.19	3.58	3.85	3.92	3.31	3.62	2.99	2.77	2.69	2.17	36.46

Source: St. Louis City Weather Bureau, Missouri

Footnotes:

1. Data for the years 1837 to 1930, inclusive, were obtained from Weather Bureau publication "Climatic Summary of the United States," Section 55 - SOUTHEASTERN MISSOURI, p. 55-15.

2. Data for the years 1951 to 1960, inclusive, were obtained from Weather Bureau publication "Climatic Summary of the United States, Missouri," p. 23.

3. Data for other years were obtained from monthly Weather Bureau publication, "Climatological Data," for Missouri.

4. The St. Louis City Weather Bureau Station has had many locations in downtown St. Louis throughout the years. Since June 26, 1968, the station has been located at the St. Louis Gateway Arch.

5. A dash (-) is shown for months when data was not available in the Weather Bureau records.

TABLE A-7
MALINE CREEK
PRECIPITATION DATA (1958-1967)

RAINFALL

	Days of +.01 inch	Mean Monthly	Maximum Monthly	Minimum Monthly	Maximum in 24 Hours
Jan	8	2.2	3.56 (1962)	0.38 (1961)	2.16 (1967)
Feb	7	2.2	4.12 (1966)	0.25 (1963)	2.56 (1959)
Mar	10	3.2	5.54 (1963)	1.09 (1966)	1.84 (1962)
Apr	10	3.6	6.03 (1966)	1.37 (1959)	2.20 (1966)
May	11	3.8	7.25 (1961)	1.38 (1965)	2.90 (1961)
Jun	10	3.9	7.97 (1960)	0.47 (1959)	3.29 (1960)
Jul	9	3.3	7.81 (1958)	1.26 (1966)	3.16 (1958)
Aug	8	3.6	3.72 (1966)	0.98 (1960)	1.86 (1958)
Sep	7	3.0	4.33 (1967)	0.76 (1960)	2.25 (1968)
Oct	7	2.7	3.81 (1959)	0.46 (1965)	1.71 (1963)
Nov	8	2.7	5.74 (1968)	0.71 (1962)	2.53 (1963)
Dec	9	2.2	6.20 (1967)	0.32 (1958)	1.90 (1967)

SNOW AND SLEET

	Mean Monthly	Maximum Monthly	Maximum in 24 Hours
Jan	4.4	13.2 (1962)	11.2 (1958)
Feb	3.9	12.9 (1961)	8.3 (1966)
Mar	4.7	22.3 (1960)	10.0 (1958)
Apr	0.1	1.8 (1957)	1.0 (1957)
May	T	T (1944)	T (1944)
Jun	0.0	0.0 --	0.0 --
Jul	0.0	0.0 --	0.0 --
Aug	0.0	0.0 --	0.0 --
Sep	0.0	0.0 --	0.0 --
Oct	T	T (1967)	T (1967)
Nov	1.2	11.3 (1951)	10.3 (1951)
Dec	2.9	11.1 (1939)	5.2 (1939)

(Source: Climatological Data, St. Louis, Missouri)

Note: Means and extremes are from the weather station at Lambert Field. Annual extremes have been exceeded at other locations as follows: maximum monthly precipitation of 20.45 inches in August 1946; minimum monthly precipitation of 0.00 inches in November 1865; maximum precipitation in 24 hours of 8.78 inches in August 1946; maximum monthly snowfall of 28.8 inches in March 1912; and the maximum snowfall in 24 hours of 20.4 inches in March 1890.

TABLE A-8

MALINE CREEK

AVERAGE FREQUENCY OF THUNDERSTORMS

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1	1	3	5	8	9	7	6	4	2	1	1	48

37. Snow, sleet, and glaze occur in any or all months from early November through April. About 17 inches of snow are normally expected during the winter. Snowfall is generally light and sporadic, with most snowstorms producing less than 5 inches of snow. Maximum depths of 10 to 12 inches accumulate only during the most severe winter storms. Freezing rainstorms and glaze are not yearly occurrences. Relative humidity, the dimensionless ratio of the actual water vapor in the air at a certain temperature to the saturation vapor pressure of air at the same temperature, ranges from 50 to 60 percent during the summer months, with early morning readings near saturation (see TABLE A-9). Heavy dews are common on clear, calm nights. The relative humidity on winter mornings is 10 to 15 percent higher than in the summer. When Maritime Tropical air from the Gulf moves into the region at temperatures just below freezing, feathery frost covering all vegetation is often the result. The watershed averages 13 days of dense fog (when visibility is restricted to 1/4 mile or less) a year. Moderate fog is experienced more frequently, with an average of 27 days per year.

TABLE A-9
MALINE CREEK
MEAN RELATIVE HUMIDITY LEVELS
CENTRAL STANDARD TIME

	Midnight	6 AM	Noon	6 PM
Jan	74	78	60	65
Feb	71	75	56	59
Mar	69	77	56	56
Apr	67	74	52	51
May	71	79	55	53
Jun	75	82	56	55
Jul	76	84	57	55
Aug	77	86	55	56
Sep	79	88	56	59
Oct	71	80	50	55
Nov	75	81	59	65
Dec	77	81	65	70
Annual	74	80	56	58

38. In the St. Louis region, southerly winds prevail from May to November and northwesterly winds dominate from December to April. Wind speeds generally average between 10 an 15 miles per hour, but in severe thunderstorms and during tornado conditions, wind velocities can reach 50 to 75 miles per hour. Occasionally, wind speeds of 80 to 90 miles per hour have been recorded in the region. Since the St. Louis area lies within the so-called "Tornado Belt" or "Tornado Alley", the tornado threat is ever-present. Tornadoes have been observed every month of the year, with about 60 percent occurring during the spring-early summer months of April, May, and June. Over 20 percent of the total number were reported during May, the month of greatest frequency. The month of least activity is August, with an average of about 2 percent of this total. Within the St. Louis area, a majority of tornado activity occurs between noon and midnight, with the greatest activity between 4:00 p.m. and 6:00 p.m. The St. Louis area experienced between 100 and 200 tornadoes during a 19-year period ending in 1967. In addition to the high wind velocities, heavy rains and hail are also associated with tornadoes. Heavy showers are common, especially following a tornado.

39. The mean annual percentage of possible sunshine over the area is 59 percent. In January, the amount of average sunshine is about 20 percent less than in July. The mean daily total solar radiation for January and July are 173 and 574 Langleys, respectively. The annual mean sky cover (sunrise to sunset) is about 60 percent. Clear to partly cloudy days occur more than 66 percent of the time. Summer months register clear days or clear with scattered cumulus clouds approximately 70 percent of the time. The St. Louis area has an average of 143 clear days per year. Winters are considered to be rather cloudy, since 40 percent of the days tend to be overcast.

Air Quality

40. The Maline Creek watershed lies in an east-west orientation within St. Louis County. The linear extent of the watershed is such that large variations in air pollution are experienced from day to day, and even from hour to hour, depending on wind direction. Within the watershed, dust emissions from a cement company are an occasional problem. Lambert-St. Louis International Airport and Interstate Highways 70 and 270 contribute high levels of oxidants and carbon monoxide during peak use periods. High levels of these air pollutants, as well as various others, are transported to the watershed from industrial areas in the city of St. Louis, East St. Louis, Illinois, and Granite City, Illinois, when winds from the south to southeast prevail. In spite of these occasional problems, the Maline Creek watershed is generally in compliance with Federal air quality standards and is regarded by the St. Louis County Department of Commmunity Health and Medical Care, Air Pollution Control Branch (SLCAPCB), as one of the cleaner watersheds in the St. Louis metropolitan area. The watershed is expected to maintain this status during the foreseeable future. In the entire St. Louis area, high wind velocities persist on an annual and monthly basis, and fairly steep lapse rates frequently occur. Consequently, the area has an inherent ability to disperse pollutants, and air

pollution episodes are relatively infrequent. The SLCAPCB operates a computerized air quality monitoring program that demonstrates the good air quality of the Maline Creek area. Most parameters are monitored every 3 minutes on a daily basis. Particulate matter, the only exception, is sampled four times a month on a randomly picked day. Air quality data for monitoring sites in the Maline Creek watershed as of 30 September 1975 are given in TABLE A-10; EPA standards in effect in 1976 are given in TABLE A-11. During the period of record, particulate matter (primary), carbon monoxide (1 hour), nitrogen dioxide, and sulfur dioxide were in compliance with EPA standards. Particulate matter (secondary) exceeded the standard for 8.5 percent of the recorded values, oxidants exceeded the standard for 0.5 percent of the recorded values, and carbon monoxide (8 hour) exceeded the standard for 0.3 percent of the recorded values.

Noise

41. The importance of noise as a quality of life factor has been increasingly recognized in recent years. While an important factor, the response of individuals to noise is a complex phonomenon. Studies have shown that an individual's attitudes, beliefs, and values may greatly influence the degree to which a person considers a given sound annoying. In addition, the physical characteristics of sounds themselves may provoke varying responses. Such factors as intensity, frequency, duration, and rate of change in sound pressure level may serve to affect the perceived loudness of sound (Federal Aviation Administration, 1976). TABLE A-12 depicts the general relationship between sound levels and human responses to certain noise. Sound levels on the scale are shown as decibels on the A scale (dBA), which approximates the frequency response of the human ear. As shown in this table, noise levels in excess of appproximately 65 dBA can generally be judged to be intrusive. Another factor which influences the perception of noise as intrusive

TABLE A-10
MALINE CREEK
AIR QUALITY FOR MONOTORING SITES
IN THE MALINE CREEK WATERSHED
AS OF 30 SEPTEMBER 1975

Monitoring Site	Pollutant	Type of Standard	Averaging Time	Number of Valid Values (Primary Plus Secondary)	Number of Values Exceeding Standard	Highest Value	Arithemetic Mean
Berkeley:	Particulate matter, ug/m^3	Primary	24 hour	40	0	259	---
		Secondary	24 hour		4	230	
Jennings:	Particulate matter, ug/m^3	Primary	24 hour	19	0	203	---
		Secondary	24 hour		2	173	
Bellefontaine Neighbors:	Particulate matter, ug/m^3	Primary	24 hour	47	0	224	---
		Secondary	24 hour		3	197	
	Carbon monoxide, ppm	Primary	1 hour	5,753	0	20.6	---
		Secondary	8 hour		15	17.2	
	Nitrogen dioxide, ug/m^3	Primary and Secondary	1 year	6,678	--	--	69
	Photochemical oxidants, ug/m^3	Primary	1 hour	6,487	35	233	---
		Secondary	1 hour			219	
	Sulfur dioxide, ug/m^3	Primary	24 hour	6,067	0	220	---
		Secondary	24 hour		0	211	

Source: St. Louis County (1975).

TABLE A-11

MALINE CREEK

NATIONAL PRIMARY AND SECONDARY AMBIENT AIR QUALITY STANDARDS

Pollutant	Type of Standard	Averaging Time	Frequency Parameter	Concentration ug/m^3	Concentration ppm
Carbon monoxide	Primary and secondary	1 hour	Annual maximum[1]	40,000	35
		8 hour	Annual maximum	10,000	9
Nitrogen dioxide	Primary and secondary	1 year	Arithmetic mean	100	0.05
Photochemical oxidants	Primary and secondary	1 year	Annual maximum	165	0.08
Particulate matter	Primary	24 hour	Annual maximum	260	--
		24 hour	Annual geometric	75	--
	Secondary	24 hour	Annual maximum	150	--
		24 hour	Annual geometric mean	60[2]	--
Sulfur dioxide	Primary	24 hour	Annual maximum	365	0.14
		1 hour	Arithmetic mean	80	0.03
	Secondary	3 hour	Annual maximum	1,300	0.5
		24 hour	Annual maximum	260[3]	0.1[3]
		1 hour	Arithmetic mean	60	0.02

Source: U.S. Environmental Protection Agency (1976).

1 Not to be exceeded more than once per year.

2 As a guide to be used in assessing implementation plans for achieving the annual maximum 24-hour standard.

3 As a guide to be used in assessing implementation plans for achieving the annual arithmetic mean standard.

TABLE A-12
MALINE CREEK
WEIGHTED SOUND LEVELS AND HUMAN RESPONSE

Sound Source	dB(A)[1]	Response Criteria
	150	
Carrier deck jet operation	140	
		Painfully loud
	130	Limit amplified speach
Jet takeoff (200 feet)	120	
Discotheque		
Auto horn (3 feet)		Maximum vocal effort
Riveting machine	110	
Jet takeoff (2,000 feet)		
Shout (0.5 feet)	100	
N.Y. subway station		Very annoying
Heavy truck (50 feet)	90	Hearing damage (8 hours)
Pneumatic drill (50 feet)		
	80	Annoying
Freight train (50 feet)		
Freeway traffic (50 feet)	70	Telephone use difficult
		Intrusive
Air conditioning unit (20 feet)	60	
Light auto traffic (50 feet)		
	50	Quiet
Living room		
Bedroom	40	
Library		
Soft whisper (15 feet)	30	Very quiet
Broadcasting studio	20	
	10	Just audible
	0	Threshold of hearing

Source: U.S. Department of Transportation (1971).

1 Typical A-Weighted sound levels taken with a sound-level meter and expressed as decibels on the scale. The "A" scale approximates the frequency response of the human ear.

TABLE A-13
MALINE CREEK
DAYTIME OUTDOOR RESIDUAL NOISE LEVELS

Area	Noise Level dBA
Wilderness and rural	16-35
Suburban residential	36-45
Urban residential	46-55
Noisy urban residential and downtown city	56-76

Source: U.S. Army Corps of Engineers (1976).

or annoying is the residual noise level; that is, the average level of expected background noise for a particular area. Daytime outdoor residual noise levels vary widely and can be grouped into the approximate ranges given in TABLE A-13.

42. The position of the Maline Creek watershed in the St. Louis metropolitan area makes it susceptible to a number of noise pollution sources. Of particular interest in this report are noise levels relating to highway and air traffic, because of the location of Interstate Highways 70 an 270 and Lambert-St. Louis International Airport within or immediately adjacent to the watershed. Highways generate significant amounts of noise, particularly where they are used by bus-truck traffic. TABLE A-14 indicates the noise levels in dBA that a six-lane highway would be expected to generate during peak volume time, as well as for average periods of traffic flow. As can be seen, the noise generated by highways is still well into the intrusive range some distance from the highway right-of-way. Such noise levels can be expected in areas of the Maline Creek watershed that are immediately adjacent to I-70 and I-270. Because of its proximity to Lambert-St. Louis International Airport, portions of the watershed are exposed to significant amounts of aircraft noise. Aircraft noise data are generally reported in terms of a Noise Exposure Forecast (NEF). The relationship of this measurement technique to the dBA scale is shown in TABLE A-15.

TABLE A-14

MALINE CREEK
HIGHWAY NOISE LEVELS, dBA

Distance from edge of right-of-way (feet)	Sound levels from auto/bus/truck traffic	
	Peak	Average
0	82.7	73.6
100	76.7	72.6
200	73.7	71.4

Source: Federal Aviation Administration (1976).

TABLE A-15

MALINE CREEK
APPROXIMATE NEF AND dBA EQUIVALENCIES

Equivalent NEF	Time in excess of dBA level exceeded (minutes per day)				
	85 dBA	90 dBA	95 dBA	100 dBA	105 dBA
20 - 32	0 - 2	0 - 2	0 - 1	0 - 0.4	0
32 - 37	2 - 15	2 - 8	1 - 4	0.4 - 0.8	0
37 - 40	15 - 30	8 - 14	4 - 7	0.7 - 0.9	0 - 0.3
40 - 42	30 - 45	14 - 20	7 - 11	0.9 - 1.1	0.3 - 0.5
42 - 43	45 - 60	20 - 25	11 - 15	1.1 - 1.4	0.5 - 0.7

Source: Federal Aviation Administration (1976).

Federal Aviation Administration (1976) data indicate that in the Maline Creek watershed, the communities of Berkeley and Kinloch are within the 30-40 NEF contour areas.

Aquatic Communities

43. Lentic habitat within the Maline Creek watershed is limited to several small lakes or ponds, the largest of which is a 6.0-acre lake at January-Wabash Park in Ferguson (TABLE A-16). Interviews with owners or officials having jurisdiction over pond properties have revealed that at least some of these lakes or ponds have fish populations. Public fishing programs are provided at county and municipal facilities.

44. The lotic habitat within the Maline Creek watershed is limited to the main channel of Maline Creek and its tributaries. Poor water quality and a lack of habitat diversity limit the variety and abundance of aquatic organisms that occur in this habitat. At the Corps of Engineers' request, the EPA (1972) collected macro-invertebrates from four sites (II, III, V, and VI) on Maline Creek (PLATE A-6). Virtually all of the collected organisms were tolerant or very tolerant of various forms of pollution (TABLE A-17). The absence of pollution-intolerant (sensitive) species was attributed to poor water quality conditions, including: (1) low dissolved oxygen concentrations; (2) excessively high water temperatures during low flow periods; (3) deposition of inert and organic materials from outfalls onto favorable substrates; and (4) possible toxicity of heavy metals discharged from industrial outfalls. In a more recent Corps of Engineers' study conducted by

TABLE A-16
MALINE CREEK
LAKES/PONDS IN THE MALINE CREEK WATERSHED*

NAME	LOCATION	COMMENT	ACREAGE
Unnamed	Bellefontaine Neighbors (Bellefontaine County Park)	No information on aquatic community	1.0
Ramona Lake	Berkeley (Ramona Lake Park)	Stocked with channel catfish in 1976; fishing allowed for Berkeley residents	3.5
Unnamed, 4 ponds	Black Jack (I-270 and West Florissant	No information on aquatic community	0.5 (each pond)
January Lake	Ferguson (January-Wabash Park)	Stocked with carp, channel catfish, and largemouth bass in 1976; fishing allowed for Ferguson residents	6.0
Unnamed	Ferguson (adjacent to railroad, at Bermuda Drive and Woodstock Road)	No information on aquatic community	1.0
Unnamed, 3 ponds	Jennings (Norwood Hills Country Club)	No information on aquatic community	0.5 (each pond)
Unnamed	University of Missouri-St. Louis	Natural community of fish and other aquatic organisms; no fishing allowed; used for nature studies	1.0
Unnamed	St. Louis County (Veterans Memorial County Park)	Fish stocking limited to special summer fishing programs for children	1.5

*Information about lakes/ponds obtained by interview with appropriate officials or landowners.

TABLE A-17
MALINE CREEK
MACROINVERTEBRATES FOUND IN MALINE CREEK
17-18 NOVEMBER 1971

Pollution-Tolerant Species

Hydrozoa
- *Hydra*

Oligochaeta
- *Aeolosoma*
- Branchiobdellidae

Hirudinea
- Glossiphoniidae
- Pisciolidae

Gastropoda
- *Lymnaea*
- *Ferrissia*
- *Gyraulus*

Pelecypoda
- *Musculium*

Crustacea
- *Orconectes*
- *Asellus*

Odonata
- *Argia*

Diptera
- Tipulidae
- *Bessia*
- *Ablabesmyia*
- *Anatopynia*
- *Cricotopus*
- *Cryptochironomus*
- *Endochironomus*
- *Pentaneura*
- *Procladius*
- *Tanypus*
- *Zavrelimyia*

Very Pollution-Tolerant Species

Oligochaeta
- Naididae
- Tubificidae

Pulmonata
- *Physa*

Diptera
- *Chironomus*
- *Psychoda*
- *Glyptotendipes*

Source: Environmental Protection Agency (1972)

Southern Illinois University (SIU) personnel, various plankton, benthos, and fish were collected from Maline Creek and one tributary (Office of Research and Projects, 1976). The collections were taken from six sampling sites (I, II, III, IV, V, and VI, PLATE A-6). The plankton and benthos communities characteristically had few species or genera and were dominated by organisms that are tolerant of various types of pollution (TABLE A-18). Invertebrate groups that are commonly regarded as clean water forms, such as caddis flies (Trichoptera), mayflies (Ephemeroptera), hydras (Hydrozoa), and flatworms (Turbellaria), were absent from the samples. With the exception of Site I, the fish community within the watershed consisted almost entirely of fathead minnows, a species that is tolerant of high temperatures, high turbidity, and low oxygen concentrations (TABLE A-19). Site I, near the mouth of Maline Creek, had a fish fauna that included five Prairie species, four Big River species, four Wide Ranging species, one Lowland species, and one Ozark species, according to the faunal classification system of Pflieger (1971). The species diversity and abundance of fish at Site I were relatively high in spite of poor water quality at the site, presumably because of easy access from the Mississippi River.

Terrestrial Communities

45. Vegetation in the Maline Creek watershed was mapped for the Corps of Engineers by the Photographic Interpretation Corporation (1975). Kulfinski (1976) sampled eight sites in the watershed for dominant woody and herbaceous vegetation for the Corps of Engineers. Terrestrial fauna were surveyed primarily by field records of Corps of Engineers' biologists and by consultation with various naturalists who have compiled records of fauna found in the area. Terrestrial wildlife habitats in the Maline Creek watershed

TABLE A-18
MALINE CREEK
PLANKTON AND BENTHOS COLLECTED FROM
MALINE CREEK, APRIL-MAY 1976

Organism	Density[1]	Pollution Tolerance Tollerance
Phytoplankton		
Chlorophyta		
Chlamydomonas	67	Acid, organic
Cladocera	*	----
Oedogonium	*	----
Spirogyra	*	----
Stigeoclomium	*	Acid, organic heavy metals
Chrysophyta		
Amphora	1	----
Eunotia	4	Acid
Fragillaria	52	----
Frustula	3	----
Gyrosigma	5	----
Meridion	2	----
Navicula	30	Acid
Pinnularia	4	Acid
Synura	20	Organic
Tabellaria	3	----
Euglenophyta		
Euglena	3	Acid, organic
Zooplankton		
Rotatoria		
Brachionus	34	Alkaline
Euchlanis	*	----
Filinia	*	----
Crustacea		
Cyhdorus sphaericus	3	----
Eucyclops speratus	2	----
Macrocyclops albidus	*	----
Paracyclops fimbriatus	*	----
Benthos		
Bryozoa		
Plumatella repens	*	----
Oligochaeta		
Lumbricidae		
Lumbricus rubellus	*	----
Naididae		
Chaetogaster diastrophus	*	Organic
Dero obtusa	6	Organic
Nais pseudobtusa	696	Organic
Paranais frici	*	Organic

TABLE A-18 (Continued)

Organism	Density[1]	Pollution Tolerance
Tubificidae		
Limnodrilus spp.	340	Organic
Tubifex tubifex	*	Organic
Hirudinea		
Erpobdella	2	----
Crustacea		
Asellus brevicaudus	11	Organic
Hyalella azteca	1	----
Orconectes immunis	119	Organic
Insecta		
Coleoptera		
Tropisternus spp.	*	----
Diptera		
Ablabesmyia	6	Organic
Cardiocladius	5	Organic
Chironomus	396	Organic
Dicrotendipes	17	Organic
Orthocladius	252	Organic
Polypedilum	*	Organic
Hemiptera		
Belostoma	*	----
Ranatra	*	----
Odonata		
Aeschna	*	----
Mollusca		
Musculium	1	----
Physa integra	4	Organic

Source: Corps of Engineers' study conducted by SIU, Office of Research and Projects (1976).

[1]Density: (1) Phytoplankton - Number per liter x 10,000.
(2) Zooplankton - Number per 100 liters.
(3) Benthos - Number per square meter, except *Orconectes immunis*, which is number per 30 minutes of seining.
(4) An asterisk denotes collection during non-quantitative sampling.

TABLE A-19
MALINE CREEK
FISH COLLECTED FROM MALINE CREEK
APRIL 1976

Species	Number Collected Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	All Sites	Faunal Group [1]
Fathead minnow	22	158	14	173	49	16	432	P
Red shiner	171	11	-	-	-	-	182	P
Emerald shiner	100	-	-	-	-	-	100	BR
Sand shiner	62	-	-	-	-	-	62	P
River shiner	57	-	-	-	-	-	57	BR
Gizzard shad	20	-	-	-	-	-	20	WR
Bluegill	14	-	-	-	-	-	14	WR
Mimic shiner	14	-	-	-	-	-	14	BR
Silverband shiner	3	-	-	-	-	-	3	BR
Bigmouth shiner	1	1	-	-	-	-	2	P
Green sunfish	-	-	-	-	1	1	2	WR
Mosquitofish	2	-	-	-	-	-	2	L
Bluntnose minnow	1	-	-	-	-	-	1	WR
Quillback	1	-	-	-	-	-	1	P
Southern redbelly dace	1	-	-	-	-	-	1	O
Golden shiner	1	-	-	-	-	-	1	WR

Source: Corps of Engineers' study conducted by SIU, Office of Research and Projects (1976).

[1]Faunal group: BR - Big River, L - Lowland, O - Ozark, P - Prairie, WR - Wide Ranging.

were grouped into two general categories, representing various types of natural habitat or various degrees of disturbance for development: (1) developed tracts; and (2) undeveloped or open space tracts subcategorized as old field or regrowth (shrub), grassland, forest cover, mixed vegetative cover, and streams and ponds (See PLATE A-7). Developed or urbanized areas consist of such things as buildings, parking lots, and roads. This type of habitat is widespread in this heavily populated and urbanized area, representing 914 acres or 6 percent of the watershed. Developed areas generally have the least value as wildlife habitat, although a few species have adapted to these rather sterile areas. Bird species that would be expected to be found include common nighthawks that nest on flat roofs, chimney swifts that nest in chimneys, and pigeons that nest and roost under bridges. Mammal species would include the house mouse, Norway rat, and little brown bat. It is unlikely that any species of reptiles or amphibians would utilize this habitat type to any extent. Old field regrowth or shrub habitat, representing 21 percent of the watershed, is a successional vegetation stage in an area that has been disturbed by human activities such as clearing. Since the vegetation of this part of the Midwest originally consisted of upland forests, prairies, and flood plain forests (Kulfinski, 1976), these "old fields" would normally return to these climax communities. However, due to the urbanization within the Maline Creek watershed, it is unlikely this will happen unless the land is protected. In the urbanized Maline Creek watershed, old field habitat is often represented by vacant lots. The vegetation of these lots includes annual and perennial grasses, shrubs, vines, and small trees. Such areas are very productive for wildlife-preferred foods such as annual weed seeds, berries, and succulent growth. A variety of species use this type of habitat. Its usefulness to wildlife depends on the size of the

area as well as the adjoining habitat. The habitat value is reduced by the prevalence of human disturbance as well as a large number of domestic predators such as dogs and cats. Birds using old field habitat include the mourning dove, common crow, catbird, brown thrasher, cardinal, rufous-sided towhee, and bobwhite quail. Common mammals include the opossum, eastern mole, striped skunk, woodchuck, and eastern cottontail. If a source of water is nearby, amphibians such as the American and Fowler's toads are likely to be found. Reptiles such as the ornate box turtle, black rat snake, and eastern garter snake may occur as well. Grassland habitat consists of mowed grass found in portions of parks, areas adjacent to the interstate highways, and residential areas. Grassland represents 10 percent of the watershed. Next to the developed habitat type, this is the least productive for wildlife. The areas are usually mowed short and provide little diversity or cover. Common birds that use this habitat include the sparrow hawk, eastern kingbird, barn swallow, common crow, robin, and starling. Mammals include the eastern mole, house mouse, and eastern cottontail. Reptiles and amphibians would be unlikely visitors because of the lack of cover. Most natural vegetation has been replaced by urbanization. That which remains is largely forest cover concentrated along the northern edge of the watershed (north of I-270), on steep slopes, and along stream courses. This type of habitat covers 879 acres or 5 percent of the watershed.

46. Eight forest sites in the Maline Creek watershed were sampled by Kulfinski (1976) for the Corps of Engineers to identify existing tree, shrub, and herbaceous species. Twenty-six species of trees were identified, of which four were considered dominant on the basis of percent density, percent area, and percent frequency. These four species are the sycamore, eastern cottonwood, box elder, and

American elm. Among the 16 shrub and woody vine species, five species were dominant on the basis of frequency of distribution among sampling locations; poison ivy, raccoon grape, common elder, dogwood, and Virginia creeper. A number of herbaceous species are dominant on the basis of frequency. Among these are wild rye, fleabane, common ragweed, giant ragweed, lamb's quarter, sunflower, pokeweed, common plantain, false nettle, and white avens. Of secondary importance in frequency are spotted touch-me-not, climbing false buckwheat, goldenrod, and wild bean. Kulfinski characterized these eight sites as having groupings of relatively young individuals with a few mature individuals interspersed. This indicates serious disturbance, such as logging, in the recent past. This natural forest habitat type includes the "wildest" areas in the watershed. However, these areas are generally subject to heavy human disturbance as well as high concentrations of dogs and cats which limit their value as wildlife habitat. Nevertheless, some of the larger tracts have a high diversity of faunal species. Bellefontaine County Park (See PLATE A-11) was visited in early February 1977 when snow covered the ground about 10 inches deep. Tracks of opossum, cottontail rabbit, fox, mice, and skunk were seen. The area is also known to contain raccoon and gray squirrels. Deer are occasionally seen in the Little Creek Wildlife Area north of I-270 and just west of West Florissant Avenue. Bird species observed in Bellefontaine Park include the blue jay and tufted titmouse, as well as many other woodland species. The value of these areas for many species is that they often are refuges to which they can retreat for breeding or roosting purposes. This is especially important for the largely nocturnal mammals. It is also reported that a wooded city park often has more birds than a wooded area of equal size in a non-urban area (Eifert, 1967). This is presumably because of the scarcity of this type of habitat.

TABLE A-20

MALINE CREEK

BIRDS OBSERVED IN A SUBURBAN YARD

FERGUSON, MISSOURI, 1974-1976

Red-tailed hawk	Magnolia warbler
Mourning dove [1]	Black-throated green warbler
Screech owl	Ovenbird
Great horned owl	American redstart
Common nighthawk	House sparrow [1]
Chimney swift [1]	European tree sparrow [1]
Yellow-shafted flicker	Red-winged blackbird
Red-bellied woodpecker	Common grackle [1]
Downy woodpecker [1]	Brown-headed cowbird [1]
Yellow-bellied sapsucker	Cardinal [1]
Blue jay	Black-headed grosbeak
Common crow	Indigo bunting
Black-capped chickadee [1]	Evening grosbeak
Red-breasted nuthatch	Purple finch
Brown creeper	Pine siskin
House wren [1]	American goldfinch
Carolina wren	Rufous-sided towhee
Mockingbird [1]	Dark-eyed junco
Catbird [1]	Tree sparrow
Brown thrasher [1]	White-crowned sparrow
Robin [1]	White-throated sparrow
Hermit thrush	Fox sparrow
Swanson's thrush	Song sparrow [1]
Ruby-crowned kinglet	Harris sparrow
Starling [1]	

[1] Species known to breed in area; young observed.

Source: Brady (1978)

Reptiles and amphibians found in the naturally forested areas would be similar to those found in old field areas. Mixed suburban cover, which refers to residential areas, is extremely variable and covers the largest amount of the area in the watershed (12,517 acres or 77 percent). PLATE A-7 shows the distribution of this type throughout the watershed. This habitat type can vary in wildlife habitat value from the low-valued monoculture of a manicured lawn to a very diverse interspersion of trees, grass, and shrubs, which can be more productive of wildlife than natural forests in the watershed. TABLE A-20 shows a list of birds that were observed in a 0.25-acre suburban yard during a 3-year period. Common mammals frequently observed include tree squirrels, opossum, raccoons, and cottontails. Reptiles and amphibians are usually very limited due to human activity, especially mowing. The yard was above average in value as wildlife habitat for the area. It included a high density of vegetative cover type, ranging in size from low grass to tall oak trees and coniferous ornamentals. The value of a particular backyard or neighborhood is dependent on the attitude and land use practices of the landowners. It is often important to have a continuum of interested owners in order to develop and maintain good wildlife habitat. Many of the undeveloped habitat types, such as forest and old field, are associated with the surface drainage system and remain undeveloped because of the flooding danger. A few water birds, such as an occasional green heron and common snipe, may be found near the streams. Warblers are common along undeveloped watercourses in the spring and fall. Mammals identified include the muskrat, raccoon, and, in more urbanized areas, the Norway rat. Where water quality is not too poor, streams and adjacent areas are the best habitat in the watershed for amphibians. Depending upon their water quality and the suitability of surrounding terrestrial habitat, the ponds within the watershed provide reproduction areas

for certain amphibians. The wildlife fauna, in general, would be similar to that associated with the permanent streams. At least two ponds are used by waterfowl. January-Wabash Park Lake in Ferguson has a resident population of mallard ducks and Canada geese, as well as some domestic ducks and geese. Ramona Lake in Berkeley also has a mallard duck population. During the fall and spring, other migratory waterfowl are attracted to these ponds. The common snapping turtle lives in these ponds and will occasionally prey on the ducklings. Undeveloped or open space areas have a definite, recognized value to the surrounding urban population. Kulfinski (1976) stressed the importance of the undeveloped forest stands, since they are the only remaining wild or natural tracts in the watershed in which children can play and residents can enjoy. One area that has been set aside specifically for ecological study is the Little Creek Wildlife Area mentioned earlier. This area of old fields in various successional stages is owned and administered by the Ferguson-Florissant School District. It has been primarily used by students from this school district, but is open to other school districts as well as other residents. Anderson and Bauer (1968) list Bellefontaine and Calvary cemeteries as preferred bird watching areas in the city of St. Louis. They include about 1,000 acres of open woods and fields, appproximately 1 mile from the Mississippi River, and provide excellent winter birding for pine siskins, goldfinches, and juncos.

Pestiferous Plants and Animals

47. Many species of mosquitoes are found in the Maline Creek watershed, although only two, Aedes vexana and Culex pipiens, are of major significance. The former is important because of the frequency with which it bites man, and the latter because it is a

vector of St. Louis encephalitis. The tick, Dermacentor variabilis, and chigger, Eutrombicula spp., are important primarily from the standpoint of the discomfort caused by their bite. Ticks can transmit tularemia and Rocky Mountain spotted fever, but these diseases are extremely uncommon in St. Louis County. Another potential wildlife related disease that may be contracted within the watershed is rabies. This virus affects the central nervous sytem and is transmitted from animal to animal and from animal to man by biting. All warm-blooded animals are susceptible, but the most common vectors are skunks, foxes, bats, and rats, as well as dogs and cats. Poison ivy is a common plant in undeveloped areas. Most people have an allergic reaction and develop a rash when they come in contact with this plant.

Endangered or Threatened Species

48. Information gathered for this study has revealed that the Maline Creek watershed has no important habitat for species considered threatened, endangered, or rare, either by the U.S. Department of the Interior or the State of Missouri. However, it is possible that an endangered or threatened plant species may be found in an undeveloped area or that an animal species, especially a migratory bird, may occasionally be found in the watershed. Kulfinski (1976) found several genera that have threatened and endangered plant species, but could not identify the species due to lack of flowering materials. Nevertheless, the conclusion is that it is unlikely that any are threatened or endangered. No unique botanical communities were found. Three faunal or floral species that are either on or proposed for the Federal list prepared by the U.S. Department of the Interior may be found in the watershed (TABLE A-21). A complete discussion of these species may be found in APPENDIX I, ENDANGERED SPECIES. The peregrine falcon was a former

TABLE A-21

MALINE CREEK

NATIONALLY PROPOSED OR LISTED ENDANGERED SPECIES

MALINE CREEK WATERSHED

Species	Status
American Peregrine Falcon *Falco peregrinus anatum*	Endangered
Bald Eagle *Haliaeetus leucocephalus*	Endangered
Mead's milkweed *Asclepias meadii*	Proposed as Endangered

Source: See APPENDIX I

inhabitant but recently has been regarded as extirpated from the area. Anderson and Bauer (1968) stated that the peregrine falcon has been seen in downtown St. Louis feeding on pigeons. An occasional peregrine falcon may pass through during migration. However, the area is not important to this species The bald eagle is common along the Mississippi River during the winter months. One of these eagles may occasionally be found in the Maline Creek watershed, especially near its mouth at the Mississippi River, but the watershed is not important habitat for this species. The Mead's milkweed has been regarded as extirpated from the area. The Missouri Botanical Garden (1975) compiled a list of plant and animal species considered rare or endangered by the State of Missouri found in the St. Louis metropolitan area. The list has been revised by referring to Brohn, et al (1977). TABLES A-22 and A-23 list those plant and animal species that are found in St. Louis County and may be found in the Maline Creek watershed. It is unlikely that there is any important habitat for any listed species in the watershed. It is noted that the American elm is considered endangered in Missouri. This species is listed because of the Dutch elm disease. This disease has been infecting native elm trees and killing them for the last 50 or more years. However, the American elm was one of the three most common trees found in the watershed by Kulfinski (1976). Consequently, it is not endangered in this area.

TABLE A-22
MALINE CREEK
STATE OF MISSOURI LISTED RARE AND ENDANGERED FAUNA
MALINE CREEK WATERSHED

Species	Status [1]
AMPHIBIANS	
Salientia (Frogs and Toads)	
Wood Frog	
Rana sylvatica LeConte	E
REPTILES	
Aquamata (Lizards and Snakes)	
Smooth Green Snake	
Opheodrys vernalis (Harlan)	R
BIRDS	
Pelecaniformes (Pelicans and Allies)	
Double-crested Cormorant	
Phalacrocorax auritus (Lesson)	E
Falconiformes (Vultures, Hawks, and Falcons)	
Sharp-shinned Hawk	
Accipiter striatus Vieillot	E
Cooper's Hawk	
Accipiter cooperii (Bonaparte)	E
Bald Eagle	
Haliaeetus leucocephalus	E
Peregrine Falcon	
Falco peregrinus Tunstall	E
Cruiformes (Cranes and Allies)	
King Rail	
Rallus elegans Audubon	R
Charadriiformes (Shorebird)	
Least Tern	
Sterna albifrons Pallas	E
Stigiformes (Owls)	
Barn Owl	
Tyto alba (Scopoli)	E

TABLE A-22 (Continued)
MALINE CREEK
STATE OF MISSOURI LISTED RARE AND ENDANGERED FAUNA
MALINE CREEK WATERSHED

Species	Status [1]
MAMMALS	
Chiroptera (Flying Mammals)	
Indiana Bat	
Myotis sodalis (Miller and Allen)	R
Keen's Bat	
Myotis keenii (Merrian)	R
Carnivora (Carnivores)	
River Otter	
Lutra canadensis (Schreber)	E

[1]Status = E = Endangered
R = Rare
U = Unknown

Source: (1) Brohn, et al. (1977)
(2) Missouri Botanical Garden (1975)

TABLE A-23
MALINE CREEK
STATE OF MISSOURI LISTED RARE AND ENDANGERED FLORA
MALINE CREEK WATERSHED

Species	Status [1]
BRYOPHYTES	
Mosses	
Fontinalis disticha Hook. & Wils. ex Drumm.	E
PTERIDOPHYTES	
Lycopodiaceae (Clubmoss)	
Shining Clubmoss Lycopodium lucidulum Michx. var. lucidulum	R
Ophioglossaceae (Adder's tongue)	
Cut-leaved Grape Fern Botrychium dissectum Spreng. var. dissectum	R
ANGIOSPERM: Monocotyledons	
Poaceae (Graminaea) (Grass)	
Love Grass Eragrostis reptans (Michx.) Nees	R
Inland Salt Grass Distichlis stricta (Torr.) Rydb.	R
Cyperaceae (Sedge)	
Slender Sedge Carex praegracilis Boott	R
Douglas' Sedge Carex douglasii Boott	E
Graceful Sedge Carex gracillima Schwein.	U
Araceae (Arum)	
Arrow Arum Peltandra virginica (l.) Schott & Endl.	R

TABLE A-23 (Continued)
MALINE CREEK
STATE OF MISSOURI LISTED RARE AND ENDANGERED FLORA
MALINE CREEK WATERSHED

Species	Status [1]
Orchidaceae (Orchid)	
Spirantheses ovalis Lindl.	R
Green Adder's Mouth Malaxis unifolia Michx. f. unifolia	R
ANGIOSPERM: Dicotyledons	
Ulmaceae (Elm)	
American elm Ulmus Americana l	E
Gentianaceae (Gentian)	
Centaury Centaurium texense (Griseb.) Fern.	R
Boraginaceae (Borage)	
Puccoon or Gromwell Lithospermum latifolium Michx.	R
Lamiaceae (Labiatae) (Mint)	
Hedge Nettle Stachys hyssopifolia Michx. var. ambigua Gray	U
Scrophulariaceae (Figwort)	
Rose turtlehead Chelone obliqua L. var. speciosa Pennell & Wherry	U
Orobanchaceae (Broom-rape)	
Broom-rape Orobanche ludoviciana Nutt.	E
Asteraceae (Compositae) (Aster)	
White Prairie Aster Aster commutatus (T. & G.) Gray	R

TABLE A-23 (Continued)
MALINE CREEK
STATE OF MISSOURI LISTED RARE AND ENDANGERED FLORA
MALINE CREEK WATERSHED

Species	Status [1]
Matricaria maritima L. var. *agrestis* (Knaf) Wilmott	U
Prenanthes racemosa Michx.	E

[1]Status = E = Endangered
R = Rare
U = Unknown

Source: (1) Brohn, *et al.* (1977)
(2) Missouri Botanical Garden (1975)

Archaeological Sites

49. In order to assess the archaeological potential of the Maline Creek watershed, a comprehensive cultural resource survey was conducted by archaeologists from Soutern Illinois University-Edwardsville (Denny, 1976) for the Corps of Engineers. The investigation covered 36.2 miles of main channel and tributary channels of Maline Creek, as well as 16 specific areas pointed out to the surveyors as being potential detention sites. Standard pedestrian reconnaissance techniques were employed in addition to selective subsurface sampling procedures using shovel probes and soil augers. Only one archaeological site was found within the watershed. This site consists of a single chert flake and is considered to be of no National Register significance. The primary conclusion reached as a result of the survey was that the Maline Creek area undoubtedly contained a rich archaeological component at one time, but due to urban development, all but an insignificant portion of the record has been destroyed. From an archaeological perspective, it was determined that there is no need to consider any mitigation measures or additional site surveys.

Historic Sites

50. There are four historic resources within the Maline Creek watershed that have been identified by the St. Louis County Department of Parks and Recreation. Of special interest is the Bissel House, located at 10225 Bellefontaine Road. This structure was the home of General Daniel Bissel, former Governor of the Upper Louisiana Territory. The Bissel family owned and occupied the house from 1812 (when it was built) to 1960. The structure is an excellent example of Federal architecture type. The house is

presently owned by St. Louis County and is maintained as a historic house by the St. Louis County Department of Parks and Recreation. The house has recently been placed on the National Register. The three remaining historic landmarks within the watershed are: the Bellefontaine Methodist Church, 10600 Bellefontaine Road, built around 1885, representative of Greek Revival architecture; the "Wildwood" House located at 40 Dames Court in Ferguson, built around 1856, representative of Victorian architecture; and the Ferguson House, 432 Darst, in Ferguson, built around 1840. None of these three sites are on the National Register or presently being proposed. PLATE A-8 shows the location of each site within the watershed.

Population Characteristics

51. Since the Maline Creek watershed is located within the Bureau of the Census' St. Louis Standard Metropolitan Statistical Area (SMSA), the majority of the statistical information used in the following paragraphs was obtained from this source. Exceptions are noted as they occur in the text. PLATE A-9 shows the watershed boundary in relation to the census tracts used by the Bureau of the Census in 1970 to develop their statistics.

52. The population of the Maline Creek watershed in 1970 was 125,330, representing a 20 percent increase from 1960. This rapid growth is also reflected in the SMSA and St. Louis County population figures, as indicated in TABLE A-24. All three areas grew at an increasing rate up to 1960. However, from 1960 to 1970, population growth increased at a decreasing rate.

TABLE A-24
MALINE CREEK
TOTAL POPULATION

	1950	1960	1970	Percent Change 1960-1970
Maline Creek Watershed	40,996	104,029	125,330	20.5
St. Louis County	406,349	703,532	951,353	35.2
St. Louis SMSA	1,759,719	2,104,669	2,363,017	12.3

Source: U.S. Census of Population

Selected statistics on population characteristics of the watershed are compared with those of St. Louis County and the SMSA in TABLE A-25. Since the small portion of the watershed within the city of St. Louis consists of only .02 percent of the total watershed population, the city was omitted from the statistical presentation. The distribution of the population by age reflects changes in the birth rate that have occurred nationally as well as regionally. This has resulted in a decline in the proportion of the population in the young child cohorts. The downward trend in fertility, which began in 1957, is expected to continue and eventually reach replacement level fertility. Over half of the population 25 years and over are high school graduates, with almost 10 percent of the population having completed at least 4 years of college. These figures represent an increase over past years in the total years of schooling. The trend toward more schooling can be expected to continue and result in higher median years of education as well as a growing number of high school and college graduates. Of the total year-round housing units, about 20 percent were in structures with two or more units. The average number of persons per household, 3.3, represents a decline over past decades. Despite the preponderance of single family dwellings, a definite trend toward multiple units and fewer people per unit is apparent. The economic

TABLE A-25
MALINE CREEK
POPULATION CHARACTERISTICS

	Maline Creek Study Area	St. Louis County	St. Louis SMSA
Total Population (in thousands)	125.3	951.4	2,363.0
Age			
Under 18	35.1%	36.1%	35.5%
65 and over	7.8%	7.7%	9.8%
Median age	28.0	27.9	28.2
Education			
Total 25 years and over (in thousands)	67.7	513.9	1,282.0
No school years completed	.6%	.7%	1.0%
Eight years school completed	89.2%	91.2%	67.0%
High school graduates	51.0%	60.5%	48.0%
Four years college or more	9.3%	16.1%	10.1%
Median years	12.0	12.3	11.7
Housing			
Total year-round housing (in thousands)	38.6	291.6	784.0
Vacant - for sale or rent only	1.6%	2.1%	4.5%
Occupied	97.8%	97.1%	93.9%
1.01 or more persons per room	8.3%	6.9%	10.0%
Median value-owner occupied	$16,900	$18,800	$16,300
Employment			
Civilian labor force (in thousands)	53.5	398.0	944.5
Percent of civilian labor force employed	95.9%	96.9%	95.1%
Percent of total population employed	40.9%	40.4%	38.0%
Income 1969			
Total families (in thousands)	32.6	245.3	595.7
Less than poverty level	3.7%	4.9%	8.1%
Greater than $15,000	27.2%	33.3%	22.9%
Median	$11,628	$11,183	$8,831

Source: U.S. Census of Population, 1970.

indicators of employment and income indicate that the watershed is similar to the region. Some minor variations include the facts that the watershed had fewer families below the poverty threshold ($3,743 for a non-farm family of four in 1970) and that the median income was slightly higher.

Major Skills and Occupations

53. In 1970, the civilian labor force within the watershed consisted of 53,500 employees. About 95.9 percent were employed at that time. Current unemployment rates are unavailable for the watershed. However, the average 1975 rates for the St. Louis SMSA and St. Louis County were 8.6 and 6.0, respectively. The figures representing St. Louis County can be considered relatively representative of the present condition in the Maline Creek watershed. A summary of the employed civilian workers by occupation group in 1970 is presented in TABLE A-26. The largest single occupation group was clerical workers, representing 23.6 percent, followed by professional/technical with 15.8 percent. These figures reflect the high white collar employment of civilian workers which is typical of urban/suburban areas. The largest source of employment is within the manufacturing industries, as indicated in TABLE A-27. There is some manufacturing within the study area, but all of the municipalities combined have fewer than 25 manufacturing industries with an average of less than 20 employees per industry ("Missouri Directory of Manufacturing and Mining - 1971," Missouri Division of Commerce and Industrial Development). However, the area is near major industrial areas in St. Louis County as well as adjacent to much industrial activity in the city of St. Louis. Employment opportunities within the watershed are limited primarily to sales, clerical, and service work. As a source of employment,

TABLE A-26
MALINE CREEK
EMPLOYMENT BY OCCUPATION, 1970

Occupation	Number (in thousands)	Percent
Professional/Technical	8.1	15.8
Non-farm Managers/Administrators	4.0	7.8
Sales Workers	4.3	8.4
Clerical	12.1	23.6
Craftsmen/Foremen	8.0	15.6
Operatives, Except Transport	5.8	11.3
Transport Equipment Operatives	2.1	4.1
Non-farm Laborers	1.7	3.3
Farm Workers	0.1	0.2
Service Workers	4.8	9.3
Private Household Workers	0.3	0.6
TOTAL	51.3	100.0

Source: U.S. Census of Population, 1970.

TABLE A-27
MALINE CREEK
EMPLOYMENT BY INDUSTRY, 1970

Industry	Number (in thousands)	Percent
Construction	2.5	4.9
Manufacturing	16.2	31.6
Transportation	2.9	5.6
Communications/Utilities/Sanitary Services	1.5	2.9
Wholesale Trade	2.9	5.6
Retail Trade	8.7	17.0
Finance/Insurance/Real Estate	2.7	5.3
Business and Repair Services	1.6	3.1
Personal Services	1.6	3.1
Health Services	1.9	3.7
Educational Services	3.6	7.0
Other Professional and Related Services	1.9	3.7
Public Administration	2.8	5.5
Other Industries	0.5	1.0
TOTAL	51.3	100.0

Source: U.S. Census of Population, 1970.

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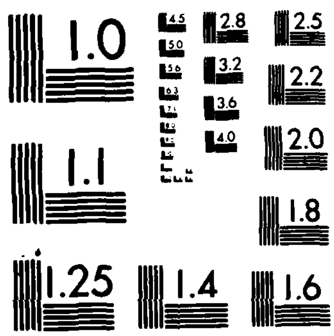

MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

the area is more commercially oriented than manufacturing. Evidence of this is that approximately four times as much land is devoted to commercial land uses than industrial land uses. Commercial land use accounts for about 5 percent of the total usage. Also, the 17 percent employment found within the retail trade industries indicates the importance of commercial centers to the area's economy. In addition, almost all of the residents work in St. Louis County or the city of St. Louis.

Personal Income

54. Personal income is income received by the area's residents from all sources. It is measured before deduction of income and other personal taxes, but after deduction of personal contributions to social security, government retirement, and other social insurance programs. It consists of wages and salaries, other labor income, proprietor's income, property income, and transfer payments (i.e., income from social insurance funds, veteran pensions, and private payments to individuals for which no services are rendered). Total personal income for the Maline Creek watershed was adapted from OBERS figures for the St. Louis SMSA. The acronym OBERS is widely used to represent as a source, the unified efforts of the Office of Business Economics (renamed the Bureau of Economic Analysis in 1972) and the Economic Research Service. In 1970, total personal income in 1967 dollars was $473,000,000. Per capita income, derived by dividing total personal income for a year by the area's population, was $3,776. This reflects a 2.8 percent annual increase from the 1950 figure of $2,154. Because these figures are in comparable 1967 dollars, thereby adjusting for the declining purchasing power of the dollar, a real and substantial increase in income has occurred. This trend is expected to continue and result in a 2020 figure of $13,900 (OBERS, Series E, 1972).

Land Use

55. Existing (1975) land use data for the Maline Creek watershed was compiled by the Corps of Engineers from the land use map developed for the Corps of Engineers by the Photographic Interpretation Corporation of Hanover, New Hampshire (PLATE A-10). The bases for the map were low altitude, panchromatic aerial photography flown in April 1975, in conjunction with follow-up ground surveys of land parcels that were difficult to categorize using only air photos. TABLE A-28 presents the breakdown of acreage into land use categories for existing (1975) conditions. For comparison, 1957 land use information compiled by the St. Louis District from 1957 air photos is also presented.

TABLE A-28
MALINE CREEK
1957 AND 1975 LAND USE

	1957		1975	
Catetory	Acres	% of Total	Acres	% of Tota
Residential	3,478	21.5	10,141	62.7
Commercial-Industrial	373	2.3	1,146	7.1
Public-Recreation	1,540	9.5	2,062	12.8
Agricultural-Vacant	10,779	66.7	2,821	17.4
TOTAL	16,170	100.0	16,170	100.00

As can be seen from TABLE A-28, the Maline Creek watershed is a highly urbanized area. The urbanized portion of the watershed, represented by the sum of all land use categories except Agriculture-Vacant, increased significantly during this period from 33.3 percent of the total acreage to over 82 percent. Residential land use made the most dramatic change, increasing from 21.5 percent of the total acreage in 1957 to nearly 63 percent by 1975. A major contributing factor to this increase in residential acreage during

this period was rapid development of high density apartment complexes. Transportation routes have served as the primary urbanization catalyst. Major routes are I-70, I-270, Natural Bridge Road, Florissant Road, Halls Ferry Road, West Florissant Avenue, U.S. 367, Bellefontaine Road, Chambers Road, the Burlington Northern Railroad, and the Norfolk and Western Railroad. Commercial activity within the watershed is located primarily along the major motor vehicle thoroughfares, while industrial concerns are concentrated near the mouth of Maline Creek and along the Norfolk and Western Railroad near the municipality of Ferguson.

Agricultural Development

56. As noted previously, the Maline Creek watershed is predominately an urban/suburban area. In 1975, about 17 percent of the land was either devoted to agriculture or it was vacant. However, only 12 percent of this figure, or about 2 percent of the total acreage, was actually used for agriculture. This accounted for about 350 of the total 16,170 acres. The farm acreages tend to be devoted to such uses as vegetable truck farm production rather than large-scale grain crops. Employment also reflects the minimal influence of agriculture within the watershed. In 1970, fewer than 100 persons (about 0.2 percent of the total employment) were employed as farm workers. Agriculture will become even less important to the area as further development occurs.

Outdoor Recreation Areas

57. The inventory of outdoor recreation areas conducted for this study consists of existing designated parks within the boundaries of the Maline Creek watershed. Parks outside of the watershed are

identified and addressed by the Metro Study. Within the boundaries of the watershed, there is a total of 737.0 acres of parkland, or about 10 percent of the total park acreage within St. Louis County. The park acreage within the Maline Creek watershed consists of 318 acres of metro-county parks, 196 acres of district parks, and 223 acres of neighborhood parks. A metro-county park is defined as a park having between 100 and 500 acres, or a site having unique historic and/or archaeological significance. The district parks contain between 20 and 100 acres, while neighborhood parks have between 5 and 20 acres. Vest pocket parks of 2 acres or less were omitted from the inventory. TABLE A-29 presents the breakdown of the existing park acreage according to park type, name, jurisdiction, and acreage. PLATE A-11 shows the location of the existing parks. Definitions of the terminology used in TABLE A-29 are as follows:

a. Partially Developed: Parklands where construction of park facilities is incomplete.

b. Historic House: A site which is maintained primarily for its historic interest, although recreation activities may be included at the site.

c. Day Use Facilities: Where recreation is intended for short-term use such as picnicking, tennis, and swimming.

d. Undeveloped: Sites purchased for recreation use but where construction of facilities has not commenced.

TABLE A-29
MALINE CREEK
EXISTING PARKS
METRO-COUNTY PARKS

NAME	JURISDICTION	COMMENT	ACREAGE
Bellefontaine	St. Louis County	Partially Developed	185.0
Bissel House	St. Louis County	Historic House	9.0
Veteran's Memorial (North County Recreation Complex)	St. Louis County	Partially Developed 50% within basin	123.5
		Subtotal	317.5
		Say	318.0

DISTRICT PARKS

NAME	JURISDICTION	COMMENT	ACREAGE
Endicott	St. Louis County	Day Use Facilities	20.0
Dunegant	Florissant	Day Use Facilities	52.0
Koeneman	Jennings	Day Use Facilities	42.0
Forest Wood	Ferguson	Day Use Facilities	28.0
January-Wabash	Ferguson	Day Use Facilities	24.0
Hudson Road	Ferguson	Day Use Facilities	30.0
		Subtotal	196.0

NEIGHBORHOOD PARKS

NAME	JURISDICTION	COMMENT	ACREAGE
Bon Oak	St. Louis County	Day Use Facilities	14.0
Dellwood	St. Louis County	Day Use Facilities	14.0
Kinloch	St. Louis County	Day Use Facilities	7.3
Musick	St. Louis County	Day Use Facilities	7.4
Tanglewood	St. Louis County	Day Use Facilities	5.8
Bangert	Florissant	Day Use Facilities	11.0
Lions	Jennings	Day Use Facilities	11.0

TABLE A-29 (Continued)
MALINE CREEK
EXISTING PARKS
NEIGHBORHOOD PARKS (Continued)

NAME	JURISDICTION	COMMENT	ACREAGE
Normandy	Normandy	Day Use Facilities	7.0
Ramona	Berkeley	Day Use Facilities	11.0
Unnamed (5501 Bermuda)	Berkeley	Undeveloped	10.1
Springdale	Berkeley	Day Use Facilities	6.0
Vann Lane	Berkeley	Day Use Facilities	6.0
St. John	St. John	Day Use Facilities	3.7
Norman Meyers	Overland	Day Use Facilities	7.0
Moline Acres	Moline Acres	Day Use Facilities	9.0
St. Cyr	Bellefontaine Neighbors	Day Use Facilities	5.8
Unnamed (Chambers Road)	Bellefontaine Neighbors	Undeveloped Nature Reserve	10.0
Unnamed (9669 Bellefontaine Road)	Bellefontaine Neighbors	Undeveloped Day Use Facilities	5.3
Bissel Hills	Bellefontaine Neighbors	Day Use Facilities	4.7
Wayside	Ferguson	Day Use Facilities	7.0
Volz-Dellwood	Dellwood	Day Use Facilities	5.8
Dellwood Recreation Center	Dellwood	Partially Developed	8.3
Unnamed (8803 Kendall)	Bel-Ridge	Undeveloped	5.2

TABLE A-29 (Continued)
MALINE CREEK
EXISTING PARKS
NEIGHBORHOOD PARKS (Continued)

NAME	JURISDICTION	COMMENT	ACREAGE
Unnamed (Foxlair & Foxpath)	Bel-Ridge	Undeveloped	14.5
Klaemen	Cool Valley	Undeveloped	2.3
		Subtotal	223.4
		Say	223.0

TOTAL EXISTING PARK ACRES	
Metro-County Parks	318.0
District Parks	196.0
Neighborhood Parks	223.0
	737.0

CONDITIONS IF NO FEDERAL ACTION TAKEN

Land Use

58. In order to identify the future without project land use configuration, this study used the future land use plan representing "end state" (2020) conditions developed by the St. Louis County Department of Planning for St. Louis County's "General Plan." This future land use plan has been approved and adopted by the St. Louis County Government. Working from this plan, the St. Louis District estimated the acreages within the Maline Creek watershed consistent with the land use categories used in TABLE A-28. TABLE A-30 shows the comparison of these estimates to the existing (1975) conditions presented earlier.

TABLE A-30

MALINE CREEK

1975 AND 2020 LAND USE

	1975		2020	
Catetory	Acres	% of Total	Acres	% of Total
Residential	10,141	62.7	11,070	68.4
Commercial-Industrial	1,146	7.1	1,900	11.8
Public-Recreation	2,062	12.8	2,460	15.2
Agricultural-Vacant	2,821	17.4	740	4.6
TOTAL	16,170	100.0	16,170	100.00

Projected Population, Employment, and Income

59. Three different sources were used to obtain the population projections in TABLE A-31. They are OBERS and two regional sources. The OBERS area used was SMSA 194 St. Louis, Missouri-Illinois. This was the smallest and most representative OBERS area containing the study area. The OBERS projections should be considered to represent the maximum growth anticipated; from 125,330 in 1970 to 168,000 by 2020. This represents an average annual growth rate of about 0.6 percent, which is substantially less than the average 5.7 percent per year between 1950 and 1970. This declining growth rate is expected for several reasons. Due to the already highly developed nature of the watershed, there are fewer development and growth opportunities. Also, a drop in persons per household from the current 3.3 is anticipated as young adults and elderly tend to live by themselves, and as families tend to have fewer children. However, the trend toward multiple dwelling units, which now account for about 20 percent of the housing units, should continue and allow for increased density (from the current 7.8 to the projected 10.4 persons per acre) and absorption of much of the projected growth resulting from natural increases and in-migration. Natural increase is expected to be conditioned by the nationwide decline in the fertility rate which began in 1957 and is expected to continue at least until replacement fertility is reached. After 2020, no further significant growth in population is expected.

60. The projected employment to projected population ratio is shown in TABLE A-31. It reflects a gradual increase in the participation rate from 41 percent in 1970. These rates are based on the assumption that the regional rates will tend toward the national average. Increased employment and increased population are considered two interrelated factors when anticipating growth. It is assumed in making these projections that workers will tend to migrate

TABLE A-31
MALINE CREEK
POPULATION PROJECTIONS

Year	Projected Population: (1)	(2)	(3)	(4)	Employment/Population Participation Rate, %
1980	133,000	136,000	138,000	147,000	43
1990	142,000	140,000	146,000	157,000	43
2000	146,000	143,000	150,000	162,000	45
2010	149,000	145,000	153,000	166,000	44
2020	150,000	146,000	154,000	168,000	44

Based on projections from:

(1) St. Louis Department of Planning, 1975.

(2) and (3) EWGCC, 1974.

(4) OBERS, Series E, 1972.

to areas of economic opportunities and away from declining areas. An indication of increased economic opportunities is seen in the specific employment projection for the major employer of the area's residents - the manufacturing industries. The figures in TABLE A-32 were derived and adapted from OBERS projections for the St. Louis SMSA. Manufacturing employment was broken down into Standard Industrial Classification (SIC) levels for development of these projections.

TABLE A-32
MALINE CREEK
PROJECTED MANUFACTURING EMPLOYMENT

YEAR	NUMBER (In Thousands)
1970	16.2
1980	19.1
1990	21.0
2000	23.7
2010	26.6
2020	29.5

Source: Unpublished report, "SMSA Value Added Projections," 1973, based upon:
1. "Population and Economic Activity in the United States and Standard Metropolitan Statistical Areas, Historical and Projected," Environmental Protection Agency, July 1972.
2. OBERS, Series E, 1972.

The projected manufacturing employment represents an average annual increase of 1.2 percent from 1970 to 2020 compared with a 0.6 percent projected population increase. This reflects the projected increase in the employment to population participation rate. However, it also indicates the continued and increasing importance of manufacturing on employment as the projected increase would also result in an increase in the proportion of the labor force involved in manufacturing industries.

61. Projected total personal income and per capita income for the study area are contained in TABLE A-33. Per capita income, total personal income divided by the area population, is expected to increase from $3,776 in 1970 to $13,900 by 2020. In comparable 1967 dollars, this is a 2.6 percent annual rate of increase over the 50-year period. Despite a gradual decline in per capita income relative to the United States as the region moves toward the national average, the area is projected to remain significantly above the national average.

TABLE A-33
MALINE CREEK
TOTAL PERSONAL INCOME AND PER CAPITA INCOME

Year	Total Personal Income In 1967 Dollars	Per Capita Income In 1967 Dollars	Per Capita Income Relative to U.S. (U.S. = 1.00)
1970	473,000,000	3,776	1.09
1980	750,000,000	5,100	1.07
1990	1,021,000,000	6,500	1.07
2000	1,393,000,000	8,600	1.06
2020	2,335,000,000	13,900	1.05

Source: Adapted from OBERS, Series, E, 1972.

Other

62. The without project conditions specifically involving flooding, recreation and the environment are discussed later in this Appendix under "Problems, Needs, and Opportunities."

Areas Subject to Flooding

63. The areas subject to flooding under existing and future without project conditions are shown in APPENDIX D, Hydrology and Hydraulics. Under existing conditions, there are approximately 864 acres within the standard project flood plain (SPFP). The predominant land use activity is residential which represents 440 acres, or 50.9 percent of the total acreage. TABLE A-34 shows the breakdown of the SPFP acreage by land use type for existing conditions (1975).

TABLE A-34
MALINE CREEK STANDARD PROJECT FLOOD PLAIN
1975 LAND USE

CATEGORY	ACRES	PERCENT OF TOTAL
Residential	440	50.9
Commercial-Industrial	44	5.1
Public-Recreation	93	10.8
Vacant-Agricultural	287	33.2
TOTAL	864	100.0

The residential land use is primarily composed of single family dwelling units. There are approximately 225 structures (8.8 percent) with two or more units, while there are approximately 2,335 structures (91.2 percent) that are single family residences. The average number of persons per household within the SPFP (3.3) is assumed to be the same as the rest of the watershed (125,330 persons divided by 38,600 units and rounded off). This figure is approximate since the area outside of the SPFP contains a higher percentage of multi-unit structures than the SPFP. The total 1970 population within the SPFP is approximately 11,500 (number of units, 3,487, x number of persons per household for watershed (3.3 taken from the U. S. Census of Population, 1970) = 11,507).

64. Five of the 25 manufacturing concerns found in the Maline Creek watershed ("Missouri Directory of Manufacturing and Mining -1971," Missouri Division of Commerce and Industrial Development), are located within the SPFP. In comparison, there are 62 commercial enterprises within this same geographic area indicating that the SPFP is more commercially oriented than manufacturing oriented. Consequently, employment opportunities are primarily in the sales, clerical, and service work fields. However, due to the limited amount of employment opportunities within the SPFP, as compared to its population, most of Maline Creek's residents work outside the flood plain. Estimated total personal income for the residents of the SPFP was derived from OBERS figures for the St. Louis SMSA. Total personal income for 1970, in 1967 dollars, was $473,000,000. Per capita income, found by dividing total personal income by the population, is $3,776.

65. Under the future without project conditions (2020), the amount of acreage within the SPFP increases only 2 acres, to a total of 866. Consequently, there is only a minor change in this

flood plain's characteristics under this condition. Population is estimated to increase by 200, to a maximum of 11,700. It is estimated that 231 multi-family structures and 2,380 single family units will be contained within the future (2020) SPFP. No net additional manufacturing concerns are expected. However, there are two additional commercial enterprises included. Employment opportunities within the future without project SPFP will exhibit minimal changes from the existing conditions. TABLE A-35 displays the projected total personal income and per capita incomes for residents of the SPFP through the year 2020. In the comparable 1967 dollar figures displayed, there is a 2.6 percent annual rate of increase over the 50-year period.

TABLE A-35
TOTAL PERSONAL AND PER CAPITA INCOMES FOR THE
MALINE CREEK STANDARD PROJECT FLOOD PLAIN

Year	Total Personal Income in 1967 Dollars	Per Capita Income: In 1967 Dollars	Per Capita Income: Relative to U.S. (U.S. = 1.00)
1970	472,000	3,776	1.09
1980	750,000	5,100	1.07
1990	1,021,000	6,500	1.07
2000	1,393,000	8,600	1.06
2020	2,335,000	13,900	1.05

SOURCE: Adapted from OBERS, Series E, 1972.

Historical Flood Damages

66. The highest flood observed in the Maline Creek watershed in the past 34 years was the flood of June 14-15, 1957. The approximate area inundated by this flood occurrence is delineated on the map presented as PLATE A-12. This inundation map reflects conditions which existed in 1957 and is taken from the open file USGS report

"Floods in Maline Creek Basin, St. Louis County, Missouri," by Donald W. Spencer and Leland D. Hauth (1968). Conditions presently existing in the channels and flood plain would alter the inundation pattern for a storm similar to that of June 1957. Therefore, comparability of the 1957 event and the same event under present conditions would be difficult. However, in order to approximate inundation damages for the 1957 event under existing conditions, damages were calculated using the 1957 flood profile elevations obtained from the above-referenced report. The USGS report cited includes only information for the 1957 flood event profiles for the main channel, Blackjack Creek (Tributary MD), and Dellwood Creek (Tributary MD-1). Using these profiles, total inundation damages caused by the 1957 event under existing conditions are estimated to be $20,700,000 for just the three areas analyzed. The flood of April 1979 caused damages of $19,012,000 of which $2,515,000 was caused by Mississippi River backwater flooding and the remainder was headwater flooding. This flood event verified the accuracy and calibration of the mathematical computer flood modeling developed for this Maline Creek Survey Report.

Existing Flood Damages

67. The occurrence of a 100-year flood event would cause inundation damages to 2,527 residential units and 56 commercial/industrial concerns. A standard project flood occurrence would cause inundation damages to 3,487 residential units and 67 commercial/industrial concerns. TABLE A-36 shows a more detailed breakdown of the units affected by the flood events studied. Total damages are $17,923,000 for the 100-year event, and $38,050,700 for the standard project flood event, under existing conditions. Average annual damages are $3,447,500. TABLE A-37 shows the breakdown of the total damages by reach and event for residential units. TABLE A-38 shows the identical breakdown for commercial units. Average annual damages are displayed by reach in TABLE A-39. Damage reaches are shown on PLATE A-13.

TABLE A-36
MALINE CREEK
Residential and Commercial Unit Allocation By
Flood Event For Existing Conditions

FLOOD EVENT

Reach	Unit Type	1 Year	2 Year	5 Year	10 Year	25 Year	50 Year	100 Year	SPF
M1	Res.	-0-	-0-	-0-	5	28	43	60	128	
	Comm.	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-	
M2	Res.	-0-	-0-	12	18	18	20	22	28	
	Comm.	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-	
M3	Res.	-0-	6	40	40	44	47	49	52	
	Comm.	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-	
M4	Res.	1	2	24	28	33	43	47	64	
	Comm.	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-	
M5	Res.	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-	
	Comm.	-0-	2	2	2	3	3	3	3	
M6	Res.	6	48	105	135	187	229	238	317	
	Comm.	-0-	-0-	-0-	-0-	2	2	2	3	
M7	Res.	-0-	-0-	-0-	5	10	10	100	171	
	Comm.	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-	
M8	Res.	5	114	281	298	355	490	583	697	
	Comm.	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-	
M9	Res.	-0-	35	42	46	65	85	117	216	
	Comm.	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-	

TABLE A-36 (Continued)
MALINE CREEK
Residential and Commercial Unit Allocation By
Flood Event For Existing Conditions

		FLOOD EVENT							
Reach	Unit Type	1 Year	2 Year	5 Year	10 Year	25 Year	50 Year	100 Year	SPF
M10	Res.	10	14	28	34	48	50	58	88
	Comm.	-0-	-0--	1	1	2	2	2	2
M11	Res.	50	67	83	99	109	109	109	110
	Comm.	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-
M12	Res.	73	82	113	128	172	183	189	233
	Comm.	-0-	2	23	24	27	27	27	29
M13	Res.	5	13	41	57	58	68	68	107
	Comm.	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-
M14	Res.	-0-	6	45	60	89	96	112	142
	Comm.	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-
M15	Res.	-0-	-0-	8	37	48	51	51	62
	Comm.	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-
M16	Res.	18	32	54	63	73	79	101	133
	Comm.	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-
MA	Res.	-0-	1	17	44	44	54	54	54
	Comm.	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-
MB	Res.	-0-	-0-	15	19	24	27	27	57
	Comm.	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-

TABLE A-36 (Continued)
MALINE CREEK
Residential and Commercial Unit Allocation By
Flood Event For Existing Conditions

Reach	Unit Type	1 Year	2 Year	5 Year	10 Year	25 Year	50 Year	100 Year	SPF
		FLOOD EVENT							
MC	Res.	8	18	35	46	54	70	76	135
	Comm.	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-
MD1	Res.	-0-	-0-	3	18	37	47	73	93
	Comm.	-0-	-0-	-0-	-0-	-0-	-0-	1	1
MD2	Res.	9	38	52	63	82	82	109	161
	Comm.	-0-	-0-	-0-	-0-	-0-	12	12	12
MD3	Res.	10	10	20	24	28	28	32	50
	Comm.	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-
MD4	Res.	1	8	10	13	22	26	34	55
	Comm.	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-
MD5	Res.	-0-	-0-	2	23	41	55	60	71
	Comm.	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-
MD6	Res.	-0-	-0-	6	9	9	12	14	55
	Comm.	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-
MF1	Res.	-0-	-0-	1	2	9	15	19	35
	Comm.	-0-	-0-	-0-	-0-	-0-	-0-	-0-	3
MF2	Res.	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-
	Comm.	1	1	1	1	1	1	1	1

TABLE A-36 (Continued)
MALINE CREEK
Residential and Commercial Unit Allocation By
Flood Event For Existing Conditions

Reach	Unit Type	FLOOD EVENT 1 Year	2 Year	5 Year	10 Year	25 Year	50 Year	100 Year	SPF
MG1	Res.	1	9	16	23	24	26	27	30
	Comm.	-0-	-0-	-0-	-0-	1	2	3	4
MG2	Res.	-0-	1	4	9	11	17	17	19
	Comm.	3	3	3	3	4	4	4	8
MH	Res.	19	19	21	24	24	24	26	29
	Comm.	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-
MD1-1	Res.	-0-	-0-	-0-	-0-	10	13	15	24
	Comm.	-0-	-0-	-0-	-0-	1	1	1	1
MD1-2	Res.	8	14	20	22	30	33	36	63
	Comm.	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-
TOTALS	Res.	224	537	1100	1395	1789	2136	2527	3487
	Comm.	4	8	30	31	41	54	56	67

TABLE A-37
MALINE CREEK
TOTAL RESIDENTIAL INUNDATION DAMAGES
STANDARD PROJECT FLOOD PLAIN
EXISTING CONDITIONS ($1000)

	FLOOD EVENT							
Reach	1 yr	2 yr	5 yr	10 yr	25 yr	50 yr	100 yr	SPF
M1	0	0	0	19.5	167.8	425.8	735.3	1,974.0
M2	0	0	21.1	44.4	117.2	154.0	175.5	468.5
M3	0	12.2	116.8	116.8	246.6	309.5	357.8	673.7
M4	1.1	4.5	89.6	94.2	164.5	356.3	466.3	1,315.7
M6	12.2	36.5	165.2	278.7	630.6	845.1	1,102.9	2,520.4
M7	0	0	0	4.9	32.2	32.2	100.1	638.5
M8	19.1	122.4	653.5	770.6	1,120.9	1,388.2	2,041.3	3,910.9
M9	0	35.0	113.1	157.7	340.5	541.6	726.6	2,139.2
M10	23.9	41.8	77.5	119.3	256.0	347.6	437.0	1,133.6
M11	106.7	206.2	357.7	374.2	769.4	1,004.0	1,261.7	2,501.1
M12	206.7	352.8	593.8	768.9	947.3	1,102.8	1,241.7	2,572.6
M13	4.1	18.7	104.9	183.3	278.3	340.8	413.3	707.5
M14	0	5.4	70.9	160.5	287.1	321.0	485.1	698.9

TABLE A-37 (Continued)
MALINE CREEK
TOTAL RESIDENTIAL INUNDATION DAMAGES
STANDARD PROJECT FLOOD PLAIN
EXISTING CONDITIONS ($1000)

	FLOOD EVENT							
Reach	1 yr	2 yr	5 yr	10 yr	25 yr	50 yr	100 yr	SPF
M15	0	0	8.1	56.1	94.3	102.2	102.2	213.2
M16	23.6	84.3	144.5	200.7	322.2	368.6	496.8	1,372.5
MA	0	0.9	58.1	250.2	250.2	344.1	344.1	461.8
MB	0	0	27.4	36.6	99.0	157.6	193.0	526.7
MC	15.6	41.6	150.4	237.7	343.0	467.3	634.4	1,493.7
MD1	0	0	5.7	28.4	132.0	169.1	372.0	995.5
MD2	11.7	70.8	123.6	200.0	379.0	379.0	548.4	1,076.2
MD3	24.3	24.3	52.0	98.0	156.3	156.3	204.1	350.6
MD4	0.9	9.3	25.9	46.9	91.5	144.8	167.6	340.9
MD5	0	0	1.9	45.3	171.6	380.3	505.3	1,908.6
MD6	0	0	13.1	28.7	28.7	51.4	76.1	847.4
MF1	0	0	0.6	1.1	7.2	26.4	34.3	127.8
MG1	0.5	5.4	17.5	29.1	50.1	78.6	110.2	298.3

TABLE A-37 (Continued)
MALINE CREEK
TOTAL RESIDENTIAL INUNDATION DAMAGES
STANDARD PROJECT FLOOD PLAIN
EXISTING CONDITIONS ($1000)

	FLOOD EVENT							
Reach	1 yr	2 yr	5 yr	10 yr	25 yr	50 yr	100 yr	SPF
MG2	0	0.8	4.7	24.3	40.2	60.3	60.3	85.2
MH	20.2	20.2	33.7	44.9	44.9	44.9	45.4	64.4
MD1-1	0	0	0	0	19.6	26.5	37.8	103.3
MD1-2	5.5	18.1	62.1	69.1	102.0	121.4	144.3	236.5
TOTALS	476.1	1,111.3	3,093.3	4,490.1	7,690.2	10,247.7	13,621.0	31,757.2

TABLE A-38
MALINE CREEK
TOTAL COMMERCIAL/INDUSTRIAL INUNDATION DAMAGES
STANDARD PROJECT FLOOD PLAIN
EXISTING CONDITIONS ($1000)

	FLOOD EVENT							
Reach	1 yr	2 yr	5 yr	10 yr	25 yr	50 yr	100 yr	SPF
M5	0	507.8	673.5	822.1	973.4	1,112.5	1,154.1	1,272.3
M6	0	0	0	0	34.5	51.9	62.0	105.6
M10	0	0	31.7	31.7	1,195.9	1,528.6	1,865.0	2,750.3
M12	0	2.2	120.4	261.9	365.3	365.3	365.3	757.6
MD1	0	0	0	0	0	0	34.8	135.4
MD2	0	0	0	0	0	88.4	300.8	499.4
MF1	0	0	0	0	0	0	0	9.4
MF2	4.1	4.1	4.1	4.1	11.2	11.2	11.2	15.3
MG1	0	0	0	0	5.1	13.3	25.4	52.5
MG2	468.3	468.3	468.3	468.3	473.0	473.0	473.0	678.7
MD1-1	0	0	0	0	10.4	10.4	10.4	17.0
TOTALS	472.5	982.5	1,298.0	1,588.2	3,068.8	3,654.5	4,302.0	6,293.5

TABLE A-39
MALINE CREEK
AVERAGE ANNUAL DAMAGES

STANDARD PROJECT FLOOD PLAIN
(Existing Conditions)

Reach	Average Annual Damages $000	Reach	Average Annual Damages $000
M1	$ 31.9	MA	52.9
M2	18.9	MB	19.3
M3	59.0	MC	104.2
M4	50.7	MD1	20.9
M5	477.1	MD2	110.5
M6	137.8	MD3	46.4
M7	6.4	MD4	22.1
M8	351.7	MD5	31.2
M9	88.9	MD6	11.8
M10	185.3	MF1	1.9
M11	281.6	MF2	4.6
M12	526.2	MG1	14.8
M13	68.1	MG2	476.5
M14	53.8	MH	26.7
M15	13.5	MD1-1	2.8
M16	114.8	MD1-2	35.1
		TOTAL AVERAGE ANNUAL DAMAGES	$3,447.5

Future Flood Damages

68. Under the future without project conditions, the occurrence of a 100-year flood event would cause inundation damages to 2,550 residential units and 60 commercial/industrial concerns. A standard project flood event would cause inundation damages to 3,544 residential units and 69 commercial/industrial concerns. TABLE A-40 shows a detailed breakdown of the units affected by the standard project flood under the future without project condition. Flood damages are $18,480,500 total damages for the 100-year event and $38,547,000 total damages for the standard project event, under future without project conditions. Average annual damages are $3,768,400. TABLE A-41 shows the breakdown of the total and average annual damages by reach and selected flood events. A detailed explanation of high flood damages were calculated and contained in APPENDIX H - Economics.

TABLE A-40
MALINE CREEK
Residential and Commercial Unit Allocation By
Flood Event For Future Without Conditions

Reach	Unit Use	1 Year	2 Year	5 Year	10 Year	25 Year	50 Year	100 Year	SPF
		FLOOD EVENT							
M1	Res.	-0-	-0-	-0-	10	28	51	62	128
	Comm.	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-
M2	Res.	-0-	7	12	18	18	20	22	28
	Comm.	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-
M3	Res.	-0-	6	40	40	44	49	49	52
	Comm.	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-
M4	Res.	1	5	24	29	35	43	50	64
	Comm.	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-
M5	Res.	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-
	Comm.	1	2	2	2	3	3	3	3
M6	Res.	6	75	125	135	187	229	238	317
	Comm.	-0-	-0-	-0-	2	2	2	2	5
M7	Res.	-0-	-0-	-0-	-0-	5	10	100	171
	Comm.	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-
M8	Res.	30	114	281	298	355	513	583	697
	Comm.	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-
M9	Res.	-0-	35	42	51	65	85	117	216
	Comm.	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-

TABLE A-40 (Continued)
MALINE CREEK
Residential and Commercial Unit Allocation By
Flood Event For Future Without Conditions

		FLOOD EVENT							
Reach	Unit Use	1 Year	2 Year	5 Year	10 Year	25 Year	50 Year	100 Year	SPF
M10	Res.	14	14	34	34	48	50	58	88
	Comm.	-0-	-0--	1	1	2	2	2	2
M11	Res.	50	67	83	99	109	109	109	110
	Comm.	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-
M12	Res.	73	94	113	148	175	183	189	233
	Comm.	-0-	4	23	24	27	27	27	29
M13	Res.	5	34	41	57	58	68	68	107
	Comm.	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-
M14	Res.	-0-	35	46	60	96	96	112	144
	Comm.	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-
M15	Res.	-0-	-0-	24	37	48	51	56	62
	Comm.	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-
M16	Res.	20	41	54	63	73	100	102	139
	Comm.	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-
MA	Res.	-0-	1	37	44	54	54	54	54
	Comm.	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-
MB	Res.	-0-	-0-	17	22	29	31	34	71
	Comm.	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-

TABLE A-40 (Continued)
MALINE CREEK
Residential and Commercial Unit Allocation By
Flood Event For Future Without Conditions

Reach	Unit Use	FLOOD EVENT 1 Year	2 Year	5 Year	10 Year	25 Year	50 Year	100 Year	SPF
MC	Res.	18	18	35	46	54	70	76	140
	Comm.	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-
MD1	Res.	-0-	-0-	3	18	45	62	73	94
	Comm.	-0-	-0-	-0-	-0-	-0-	-0-	1	1
MD2	Res.	9	38	57	63	82	103	109	161
	Comm.	-0-	-0-	-0-	-0-	-0-	12	12	12
MD3	Res.	10	10	20	24	28	28	32	50
	Comm.	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-
MD4	Res.	1	8	13	20	26	26	34	68
	Comm.	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-
MD5	Res.	-0-	-0-	12	35	48	55	62	71
	Comm.	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-
MD6	Res.	-0-	2	6	9	9	12	14	55
	Comm.	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-
MF1	Res.	-0-	-0-	1	7	13	17	20	36
	Comm.	-0-	-0-	-0-	-0-	-0-	-0-	1	3
MF2	Res.	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-
	Comm.	1	1	1	1	1	1	1	1

TABLE A-40 (Continued)
MALINE CREEK
Residential and Commercial Unit Allocation By
Flood Event For Future Without Conditions

Reach	Unit Use	FLOOD EVENT 1 Year	2 Year	5 Year	10 Year	25 Year	50 Year	100 Year	SPF
MG1	Res.	1	9	16	23	24	26	27	30
	Comm.	-0-	-0-	-0-	-0-	1	1	3	4
MG2	Res.	1	1	8	10	17	17	17	21
	Comm.	3	3	3	4	4	4	7	8
MH	Res.	19	21	21	24	24	26	29	33
	Comm.	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-
MD1-1	Res.	-0-	-0-	-0-	4	13	14	17	24
	Comm.	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-
MD1-2	Res.	14	18	21	28	33	36	37	68
	Comm.	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-
TOTALS	Res.	272	653	1186	1461	1848	2234	2550	3544
	Comm.	5	10	30	35	41	53	60	69

TABLE A-41
FLOOD DAMAGES BY FLOOD EVENT ($1000)

FUTURE CONDITION-UNPROTECTED

Reach	2 Year	5 Year	10 Year	25 Year	50 Year	100 Year	500 Year
M16	$ 97	$ 186	$ 270	$ 405	$ 540	$ 637	$ 2,279
M15	10	35	65	90	112	131	241
MH	35	42	50	53	66	73	94
M14	41	108	219	301	405	476	923
M13	53	186	256	323	377	417	890
M12	499	931	1,216	1,492	1,627	1,731	4,512
MG2	521	541	558	585	671	719	985
MG1	10	22	46	72	129	167	600
MF2	4	8	10	13	15	17	22
MF1	0	1	8	20	29	119	259
M11	284	322	336	670	845	1,023	1,733
M10	62	234	413	1,625	2,002	2,311	4,348
M9	44	152	211	436	602	810	2,492
M8	162	738	872	1,401	1,832	2,201	4,472
M7	0	3	10	36	53	127	693
M6	102	303	389	782	993	1,255	2,926
MD6	3	17	24	34	50	492	920
MD5	4	54	164	337	459	653	2,365
MD4	23	55	94	132	154	306	448
MD3	36	74	119	155	180	209	474
MD1-3	0	0	0	0	0	1	14
MD1-2	39	85	108	140	151	167	382
MD1-1	0	2	15	32	52	67	157
MD2	98	193	295	507	693	886	2,071
MD1	1	14	67	160	271	560	1,399
M5	522	730	829	944	1,034	1,066	1,203
M4	17	121	174	292	419	562	1,509
MC	67	176	246	547	926	1,123	1,516
M3	18	133	166	273	331	385	743
MB	10	26	58	123	172	207	948
M2	7	44	66	129	166	210	505
MA	88	298	389	545	663	780	1,052
M1	0	25	77	289	559	816	2,038
	$2,857	$5,859	$7,820	$12,943	$16,578	$20,704	$45,213

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Outdoor Recreation Needs

69. The basic outdoor recreation needs for this study were defined in terms of land requirements, unsatisfied activities and available site opportunities. The outdoor recreation need analysis is specific to the Maline Creek watershed. The analysis for the entire metropolitan area is addressed by the St. Louis Metropolitan Area, Missouri and Illinois, Study.

70. In order to compute the land needs for outdoor recreation, the existing and expected quantities of parklands (supply) were compared with existing and projected levels of population (demand) using standards that relate recommended ratios of population to usable recreation acreage. There are different standards for different types of recreation, but one common standard that is recommended for use by the National Recreation and Park Association for Urban Areas (NRPAU) (identified in Outdoor Recreation Space Standards, NRPAU, 1955) is a minimum need for 10 acres of dedicated parks and open space available for each 1,000 people not including regional parks and open space. This standard is recognized and accepted by local government agencies. Based on the 1970 population of 125,330, the total acreage needed for public recreation under existing conditions is 1,250 acres. Since there are 737 acres of existing parks within the Maline Creek watershed, the unmet existing need is the difference between the recommended acreage (1,252) and the existing acreage (737), or 515 acres.

71. In regard to future needs, the projected population of 168,000 for the year 2020 yields a total acreage requirement of 1,680. In order to determine the anticipated supply of acreage that will be available in the year 2020 to address these needs, interviews were conducted with local parks and recreation officials. The results of the interviews are that the local officials are expecting no net

Consequently, plans which required intensive and wide spread use of such equipment are less desirable in terms of air quality deterioration than those plans which are less equipment intensive and narrower in flood control coverage. Dust pollution also falls into this category. In order to rank plans into air polluting categories it was assumed that plans which are highly construction oriented and high energy users will generate high air pollution problems. Similarly, moderate construction activity and moderate energy consumption plans will generate moderate levels of air pollution. For lower construction activities and lower energy intensive plans, smaller levels of air pollution will occur. This information allowed the ranking of air pollution by alternative as illustrated in Column (3) of TABLE B-31. High Air Pollution (HAP), Moderate Air Pollution (MAP), and Low Air Pollution (LAP) are indicated in the table. These are construed to be short-term construction problems with no long standing environmental effects.

b. Water Pollution. As indicated in the Base Study and Future Conditions Without Protection, the water quality and aquatic habitat are in poor condition at the present time. Implementation of EPA and state/local pollution abatement plans are expected to correct this problem within the next decade. Certain measures in these plans may provide additional pollution control. The plans considered in this last stage of formulation and impact assessment contain such features as detention, ingrade control structures, fish ponds, and some channel coincidental erosion control. In addition, nearly all plans include channel clearing and snagging and related cleanup operations. These measures, although developed for other purposes, would only improve water quality. In developing measures for impact assessment for water quality, the following criteria were used. Some of the alternatives covered many formulation reaches along both the main stem and tributaries. Some required more detention sites than others. As a result of this greater coverage

and detention capacity, water quality is expected to improve through the added detentions, added fish ponds, and added ingrade structures due to the greater coverage of a more comprehensive plan. Other plans impacted fewer reaches on the main stem and tributaries and fewer detentions, fish ponds, and ingrade structures. These would still improve the water quality of the ambient and expected future conditions, but not to the same degree as the more comprehensive plans. There were a few plans which did not incorporate channel measures or extensive use of non-structural components, for example, bridge removals only, selected non-strucural sites, etc. These plans would not lead to fish ponds, grade control structures, and few if any detentions. As a result there would be no improvement of water quality expected from these plans. The ranking of plans with regard to water quality involved the number of reaches receiving some type of improvement. With each reach improvement would be associated with a water quality improvement-drop structure, fish pond, or detention. The highest water quality rank was 40; the lowest was 7. Again some professional judgment had to be employed. The results are presented in Column (3) under "water."

c. Land Pollution. Land pollution includes such problems as erosion, debris, dumps, man-made structures, and mining activities. There are erosion problems along Maline Creek but the problems are not severe nor widespread. Some of these problems will be resolved as channel improvements are installed. Others will be improved by the use of detention and non-structural measures. Debris has been a persistent problem along Maline Creek - especially man-produced trash dumped into the creek. Natural debris is also persistent. A good deal of the existing debris problems will be resolved by many of the alternatives. Clearing and snagging is an integral part of nearly all alternatives. Also the MSD periodically clears problem areas. This aids in reducing the magnitude and scope of debris problems. Debris removal will be part of operation and maintenance

required in the alternatives considered. Dumps and disposal areas are few in Maline Creek. These are a problem in a few select areas under private ownership. While unsightly, they do not constitute a flood problem. Corps of Engineers' channel work includes excavations but the resulting soil removal will be used for measures such as select low level flood protectors. Man-made structures can also be a form of land pollution. Insofar as this study is concerned, some of the flood control measures tested would create this situation. Those plans which did not employ flood walls and levees were ranked as "0" meaning no unsightly man-made pollution was created (see Column (3), TABLE B-31). Those plans that used the non-structural and very small flood protectors - say 1 to 3 feet - received a rating of "1." Similarly, those plans using a medium size levee or flood wall received a rating of "2" - say 3-5 feet. Finally, those structural measures employing large levees or flood walls - between 6-12 feet - were rated as "3," the most unsightly. The details of this analysis are on file in the Urban Studies Section, St. Louis District, Corps of Engineers, for review as necessary.

123. Animals and Plants. This portion of environmental assessment focused on each alternative's impact on animal and plant species. The main thrust was based on habitat destruction/creation. An environmental analysis was conducted which ranked stream reaches in terms of their currently existing environmental quality as shown below. Those measures which tended to adversely disrupt the ambient environmental quality of priority one reaches were considered poor solutions. However, those alternative plans that improved the currently degraded nature of the environment were considered to be superior solutions.

EXISTING ENVIRONMENTAL QUALTIY

Reach	Rank Priority
M1	2
M2	2
M3	1
M4	1
M5	1
M6	1
M7	1
M8	1
M9	1
M10	1
M11	1
M12	1
M13	1
M14	1
M15	1
MD	2
MD1	1
MD2	1
MD1-1	1
MD1-2	1
MH	1
All other reaches	3

124. It was assumed that the construction of large channels in priority one reaches was the most destructive to habitat. Medium channels would be less destructive and small channels least destructive. A reach which required a large channel received a rank of "3," a medium channel ranked "2," a small channel a rank of "1," and no channel work a rank of "0." The greater a plan's rank (higher sums) the more degraded are priority one reaches. The smaller a plan's rank (lower sums) the less are construction impacts. A perfect plan - one which had no impacts on priority one reachs would have a sum of "0." A highly destructive plan would have a maximum rank of "39." These are the extremes. Bridge removals or alternations received a "0" rank because there would be little or no induced habitat destruction. It should also be remembered that habitat destruction is due to construction - not future conditions with or without a project. Future conditions without a project will lead to environmental degraditon from urbanization but are likely to improve with a project.

125. Ecosystems. Charles Krebs in Ecology, describes an ecosystem as, "a biotic community and its abiotic environment." As described earlier, the ambient ecology of the Maline Creek watershed is poor at best and shows signs of continued degredation under the stress of urbanization. Alternative plans with environmental considerations could stop this degradation and quite possibly reverse and improve the adverse trends. Some plans would do this better than others. Most plans would utilize grade structures, fish ponds, detentions, and preserved high quality environmental areas through fee simple purchase. The more comprehensive the plan, the more such features would be used. This idea was used to rank ecosystem improvements. Ecosystems would in essence be created or preserved by each plan and the more extensive the plan the greater would be ecosystem creation. All plans were reviewed with this concept in mind. The ranking of the impact on ecosystem parallels that of water quality

improvements discussed earlier. The added feature is terrestrial habitat. During the analysis of water quality, plans were ranked according to the number of reaches receiving protection, the idea being that with each reach improvement was associated a water quality improvement, i.e., fish pond, grade control structures, and detention. This analysis also makes the realistic assumption that with each reach improvement terrestrial habitat would also be preserved by actions taken by the Corps. This requires in addition that any given measure in-and-of itself does not require habitat destruction through construction actions (TABLE B-31, Column 4: animal and plant). To accomplish the task of ranking for ecosystems the following procedures were used.

126. The greater the number in Column (3) (Water Pollution) the better the plan was. The greater the number in Column (4) (Animal and Plant) the worse the plan was. The highest rank in Column (4) was 39. If the value in Column (3) under water quality was added to the value in Column (4) minus 39, an index would be formed which incorporates the positive aspects of water quality improvements with the positive aspects of habitat preservation. For example: Plan (31.2) says that there are 19 reaches which would receive flood control improvements and thusly 19 water quality related improvements. The greater the number in this column, the better is water quality improvements. The highest value for this column of any plan was 40. The larger the number in Column (4), Animal and Plant, the greater the adverse impact on habitat of construction activity. The lower this value, the greater are the positive impacts on habitat - they are preserved. The maximum negative impact value is 39. Thus:

$$19 + (39 - 13) = 45 \text{ for plan } (31.2)$$

The larger this value is, the greater will be aquatic and terrestrial habitat preservation and enhancement. The results are presented in Column (5). The highest rank was 71.

127. Endangered or Threatened Species. A careful field investigaton and resource inventory has indicated that there are no endangered or threatened species in the Maline Creek Basin (Column (6), TABLE B-31).

128. Summary of Environmental Effects Decisions. The environmental effects decision information presented in summary form in TABLE B-31 provided the rationale for identification of the selected plan of improvements. This decision process is discussed later in this report under the heading "Rationale for Selected Plan."

Nominal 100-Year Plan

129. It was recognized from the beginning of this study and has been repeatedly verified, that the fundamental water and related land resource problems of Maline Creek are basic flood control problems. The magnitude of the average annual damages ($4,145,000) also attests to the serious need for effective flood damage reduction measures. In order to insure that every possible means for reducing the severity of the flood damages had been addressed, two additional opportunities to provide 100-year flood protection were explored. One of these opportunities focused on nonstructural 100-year protection and the other on structural protection. The 100-year performance level was selected so as to accommodate the Federal Insurance Administration's (and now FEMA, Federal Emergency Management Agency) selection of 100-year floodway approximations for their regulatory program emphasis.

130. Nonstructural 100-Year Plan. The opportunity to prevent all damages occurring within the 100-year flood plain area via complete relocation was considered. Under existing conditions (1977) there are 2,527 homes plus 56 commercial structures located in the 100-year flood plain area. An initial very conservative estimate of the cost to purchase and relocate 2,527 homes plus 56 commercial establishments indicated expenditures would be in excess of 150 million dollars. The average annual cost of the nonstructural 100-year flood plain relocation plan is estimated to be approximately $21,290,000 (at 6-7/8%) exclusive of costs to relocate public facilities (i.e., roads, sewers, sidewalks, telephone lines, etc.). This high cost plus the undesirable social disruption of moving 2,527 families precluded further consideration of this opportunity to provide 100-year flood damage prevention. Protection for higher frequency floods via nonstructural solutions was even less viable.

131. Structural 100-Year Plan. The second opportunity pursued for improving flood control performance to the 100-year level was the identification of a nominal structural 100-year plan. A search of all alternative plans was made to identify any plans that could provide protection against a 100-year flood event. Also specifically noted was any possibility that Standard Project Flood (SPF) protection might be technically possible (protection at 500-year or greater levels). Of the complete range of technically possible plans studied, only one could be identified as providing nominal protection against a 100-year flood.

132. The nominal 100-year structural plan used the most extensive channel sizes reasonably possible in combination with flood walls ranging in height from 12 feet to 15 feet, plus basic detention site flood reductions. No combination of large channels and flood walls could be found which provided complete protection against the

100-year flood event. The alternative most closely approximating 100-year frequency protection was found in plan 59.9. TABLE B-32 shows the details of this alternative.

133. As TABLE B-32 illustrates, protection against an SPF event was achieved in 18 reaches where benefits might marginally exceed costs. The multi-plan model run indicated that this plan could only provide SPF protection to 17 of these 18 reaches. No attempt was made on the remaining 15 reaches because costs always exceeded benefits by a wide margin. In addition, it was reasoned that if the profiles could be lowered on the main stem reaches, it would follow that the profiles of tributary reaches would fall also. This reasoning proved to be correct. Nine of the 15 unprotected reaches indicated water surface profile improvements and subsequent damage reductions. The water surface profile fall in the protected main stem reaches led to lowered water surface elevations in the unprotected reaches and resulted in $162,000 annual benefits without any additional annual costs. In total, 17 out of 33 reaches could be protected against the SPF flood event. As indicated in TABLE B-32, average annual flood control benefits from this plan amounted to $3,649,000.

134. The next step in the process was to investigate annual costs. Four cost components were examined including: 1) flood wall elements, 2) channel costs, 3) bridge costs, and 4) easements and rights-of-way. It became obvious at this point that annual costs greatly exceeded annual benefits. Total costs are $10,197,000. The resulting BCR is 0.36. It was clear that no further analysis was needed. A decision was made to discontinue searching for potential 100-year as well as SPF flood event protection. Items not included in this search for higher flood protection performance that would further increase costs were: 1) an interior drainage system for handling water accumulating behind the walls during a severe storm,

TABLE B-32
NOMINAL 100-YEAR PLAN
PLAN 59.9 COMPONENTS
7-1/8%

Seq. No. Multi-Plan (1)	Channel Reach (2)	Measure (3)	No.Plan Damage (4)	Berm Cost (5)	Channel Cost (6)	Bridge Cost (7)	Buyouts (8)	Easement Rt./Way (9)	Total Cost (10)	Benefits (11)	Degree Protection (12)	B/C (13)	Ind. Damage (14)
4	M16	EMN8	131	73	76	43	-	7	199	131	SPF	.66	-
5	M15	EMN6	20	50	59	52	-	5	166	20	SPF	.12	-
7	MH	-	35	-	-	16	-	-	16	18	2	1.13	-
8	M14	EMB8	70	59	67	13	-	6	145	70	SPF	.48	-
9	M13	ELH8	94	75	81	-	-	7	163	94	SPF	.58	-
10	M12	ULN8	615	69	487	-	-	7	563	615	SPF	1.09	-
11	MG2	ULN8	530	44	217	-	-	4	265	530	SPF	2.00	-
12	MG1	ULN8	18	37	207	12	-	4	260	18	SPF	.07	-
N/A	MF2	-	6	-	-	-	-	-	-	-	2	-	-
N/A	MF1	-	3	-	-	-	-	-	-	1	5	-	-
15	M11	ULN8	314	37	487	13	-	4	541	314	SPF	.58	-
17	M10	ULN8	219	74	771	-	-	7	852	219	SPF	.26	-
18	M9	ULN8	99	77	795	12	-	7	891	99	SPF	.11	-
19	M8	ULN8	395	75	819	33	-	7	934	395	SPF	.42	-
20	M7	ULN8	7	55	600	16	-	5	676	7	SPF	.01	-
21	M6	ULN8	197	88	860	-	-	8	956	197	SPF	.[illegible]	-
23	MD6	-	14	-	-	-	-	-	-	14	2	-	-
24	MD5	-	47	-	-	-	-	-	-	23	2	-	-
26	MD4	-	35	-	-	-	-	-	-	18	2	-	-
28	MD3	-	51	-	-	-	-	-	-	10	2	-	-
32	MD1-3	-	-	-	-	-	-	-	-	-	100	-	-
33	MD1-2	-	55	-	-	-	-	-	-	21	2	-	-
34	MD1-1	-	4	-	-	-	-	-	-	2	5	-	-
35	M32	-	136	-	-	-	-	-	-	45	2	[illegible]	-
36	MD1	-	24	-	-	57	-	-	57	10	2	[illegible]	-
38	M5	ULN8	594	85	420	47	-	8	560	594	SPF	1.06	-
39	M4	ULN8	68	31	446	36	-	3	516	68	SPF	.13	-
43	MC	-	121	-	-	11	-	-	11	-	2	-	-
44	M3	ULN8	67	56	573	-	-	5	634	67	SPF	.11	-
47	MB	-	22	-	-	10	-	-	10	-	2	-	-

TABLE B-32 (Continued)
NOMINAL 100-YEAR PLAN
PLAN 59.9 COMPONENTS
7-1/8%

Seq. No. Multi-Plan (1)	Channel Reach (2)	Measure (3)	No.Plan Damage (4)	Berm Cost (5)	Channel Cost (6)	Bridge Cost (7)	Buyouts (8)	Easement Rt./Way (9)	Total Cost (10)	Benefits (11)	Degree Protection (12)	B/C (13)	Ind. Damage (14)
49	M2	ULN8	26	95	1083	24	-	9	1211	26	SPF	.02	-
50	MA	-	89	-	-	36	-	-	36	-	2	-	-
52	M1	RNB7	39	48	-	-	-	4	52	23	10	.44	757
			4145	1128	8048	431	-	107	9714	3649		-	757
	DET.SITE						CONFIGURATION						
1	M27	1,3	-	-	-	-	-	-	73		-	-	-
3	M22	1,3	-	-	-	-	-	-	40		-	-	-
6	MH1	2,1	-	-	-	-	-	-	57		-	-	-
13	MF1	2,1	-	-	-	-	-	-	38		-	-	-
14	MF2	3,1	-	-	-	-	-	-	66		-	-	-
16	M13	-	-	-	-	-	-	-	-		-	-	-
22	MD-1	3,5	-	-	-	-	-	-	78		-	-	-
25	MD2-2	1,3	-	-	-	-	-	-	54		-	-	-
27	MD-2	-	-	-	-	-	-	-			-	-	
29	MD1-1	1,3	-	-	-	-	-	-	77		-	-	
30	MD1-2	-	-	-	-	-	-	-	-		-	-	-
40	MD-1	-	-	-	-	-	-	-	-		-	-	-
41	MD-2	-	-	-	-	-	-	-	-		-	-	-
45	MB-1	-	-	-	-	-	-	-	-		-	-	-
46	MB-2	-	-	-	-	-	-	-	-		-	-	-
									483				

Benefits	3649
Costs	10197
Net Ben	(6496)
BCR	.36
% Dam.Red.	88%

2) closure structures, 3) residential relocations, and 4) sewer modifications. These would only add additional costs to the plan.

135. The plan illustrated in TABLE B-32 was considered a nominal 100-year plan because only $331,000 in damages from the 100-year frequency event still remained. Further, a SPF flood event would cause a devastating $28,170,000 in damages. While $331,000 may not be considered devastating, it was felt that $28,170,000 in damages would fall under the heading of a catastrophe. The plan also induced downstream damage of $756,000 from a SPF flood.

136. The nominal 100-year plan possessed additional adverse characteristics. These included: 1) the need for closure structures, 2) interior drainage, 3) residential relocations, 4) sewer modifications, 5) aesthetically unpleasant, 6) environmentally destructive, and 7) a safety trap. Some of these characteristics were briefly mentioned earlier, but a more descriptive analysis is required.

137. Closure structures are not only costly but impractical in an urban area. Someone would have to be assigned the responsibility of operating the gates and essentially be on a 24-hour alert. The predictability of a large damaging storm is guess work to a large extent. The reliability of radar, satelites, and other detecting equipment is not 100 percent accurate. There would be false alarms, misforecasts, and confusion. In an urban area these circumstances could be costly and dangerous.

138. Interior drainage would be simply too expensive. Given a BCR of 0.36, a drainage network consisting of pumps, pondage, and gravity drains would only reduce the BCR further. The nominal 100-year protection plan would require a high concrete wall. During a 100-year frequency storm, it may not be possible to pump flood

water from behind the wall rapidly enough to stop induced damages. Gravity drains would be ineffective during critical hydraulic conditions.

139. Although the plan as shown in TABLE B-32 did not include relocations, the engineering characteristics would suggest that a substantial number of homes and businesses would have to be removed. The flood walls and extensive channel improvements would require a good deal of instream storage and rights-of-way. In effect, the flood walls would have to be alined hundreds of feet from the stream. The plan would require the removal of the very source of damages subsequently reducing benefits and increasing costs. There is also a social well-being or "externality" costs to this approach. Moving hundreds of people from their homes destroys neighborhood integrity and would not likely be publicaly acceptable.

140. Sewer modifications would be extensive. There would be hundreds of flap-gates, realinements, and design modifications. Again those are added cost components contributing nothing to benefits. In addition to sewer modifications, other utilities would also have to be modified (i.e., telephone lines, roads, water mains, etc.).

141. A 12 to 15-foot concrete wall would also be aesthetically displeasing. Citizens would look out into their back yards and view a mass of concrete. Public acceptablility would be encumbered by such a measure.

142. The nominal 100-year plan is environmentally unacceptable. There are a few good environmental habitats located throughout the Maline watershed. The construction of massive channel improvements and high concrete walls would lead to the destruction of the remaining habitat areas. Substantial easements, rights-of-way, and

clearing would be required. This would be unacceptable environmentally.

143. The plan is a safety trap. If a SPF flood event occurred with 100-year protection, up to $28,170,000 event damage could result. A flood of this magnitude would be destructive to homes, industry, utilities, and may cause loss of life.

144. To summarize, the 100-year frequency plan is simply not viable. The following problems are apparent:

a. the BCR = 0.36 (does not include all costs),

b. the plan is a safety trap,

c. the plan is environmentally destructive,

d. the plan is aesthetically displeasing,

e. the displacement of people is substantial,

f. the plan induces $756,800 during a 500-year flood event,

g. the plan has $331,000 remaining damages at the 100-year event,

h. the plan protects only 17 out of 33 reaches,

i. the plan would require the purchase of large tracts of land,

j. the potential exists for $33,100,000 in SPF event damages,

k. Bridge modifications would be extensive,

l. A 24-hour team would be needed to operate closure structures.

145. Because of these over-whelming factors, further consideration of high levels of protection was discontinued.

Nonstructural Plan

146. In searching for a nominal 100-year plan, testing was made on a nonstructural plan that would relocate all flood damageable

MALINE CREEK, MISSOURI

SURVEY REPORT FOR FLOOD CONTROL
AND ALLIED PURPOSES

APPENDIX B

PLAN FORMULATION, ASSESSMENT AND EVALUATION

APPENDIX B

PLAN FORMULATION, ASSESSMENT, AND EVALUATION

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APPENDIX B

PLAN FORMULATION, ASSESSMENT AND EVALUATION

1. The purpose of this appendix is to present the results of the plan formulation process used to arrive at the recommended plan of improvements for the Maline Creek watershed. The recommended plan of improvements is the product of four comprehensive cycles of an iterative plan formulation process. Each successive cycle used an improved series of screening criteria to help focus on better solutions.

2. The basic objectives of this Maline Creek study were threefold: flood control, outdoor recreation, and environmental enhancement. TABLE B-1 is an outline that displays the generalized plan formulation process adopted for this study. The first item in each cycle (i.e., identify the problems and needs) is detailed in APPENDIX A. A very broad overview of the formulation for this Maline Creek report may be summarized as below. The remainder of APPENDIX B provides a more complete explanation of the summarized formulation results.

a. Cycle One Formulation. Three comprehensive alternatives were formulated to cover the full spectrum of highly structural to highly nonstructural solutions. Intensive public involvement was used for the selection of an intermediate solution blending some structural features into a primarily naturally oriented solution. The plan selected had a 1.5 benefit to cost ratio based on a tangible assessment of the net impact of the full range of all environmental effects.

TABLE B-1
MALINE CREEK
PLAN FORMULATION OUTLINE

I First Formulation Cycle

A. Identify Problems and Needs
B. Create Polar Solutions (i.e., Structural versus Natural)
C. Identify a Compromise Solution that has Active Public Support
D. Three Alternative Solutions Were Created in Cycle One Formulation

II Second Formulation Cycle

A. Verify Problems and Needs
B. Determine Planning Objectives
C. Check Formulation Criteria and Assumptions
D. Correct the Benefits Creditable to the Polar Solutions and the Compromise Solution
E. Verify the Intense Public Support
F. Basically, the Same Three Alternative Solutions Were Simply Improved in Cycle Two Formulation

III Third Formulation Cycle

A. Verify Problems and Needs
B. Define Planning Objectives
C. Define Formulation Criteria, Assumptions, and Approach
D. Identify All Plausible Measures to Address Each Planning Objective
E. Screen, Refine, and Improve Single-Purpose Performance
F. Develop Multi-Purpose Alternatives
G. Designate Draft NED, EQ, and "Conventional" Plan
H. 137 Alternatives Were Created in Cycle Three Formulation

IV Fourth Formulation Cycle

A. Verify Local Citizen and Local Sponsor Desires
B. Update Formulation Criteria
C. Formulate 374 Additional Alternatives to Meet All Revised Criteria
D. Also Carried Through This Last Formulation Cycle was the Cycle Three "Conventional" Plan Plus a Nonstructural Plan and a "Traditional" Plan Even Though They Did Not Pass All Screening Criteria.
E. Designate an NED, EQ and Recommended Plan.
F. A Total of 377 Plans Were Studied in Cycle Four Formulation.

b. Cycle Two Formulation. The benefits evaluation for the three plans formulated in cycle one were revised. Basically a shift of tangible benefits assessment into the intangible category resulted in a drop of the benefit to cost ratio from 1.5 to 0.9. A positive recommendation for installation of improvements was made on the basis of the substantial intangible benefits and very significant public support.

c. Cycle Three Formulation. A total of 137 alternatives were formulated and screened to find the optimum solution. Plan number 123 was the optimum flood control and environmental quality mix.

d. Cycle Four Formulation. A total of 377 additional alternatives were formulated to meet revised performance criteria. Carried through the fourth (last) formulation cycle was a nonstructural plan, a "traditional" plan and the cycle three "conventional" plan. These additional alternatives were included to insure the widest possible practical diversity in the final consideration of alternative solutions. Including a "pure" nonstructural plan through the final decision process in spite of its very poor viability was purposefully done to insure maximum flexibility in local decision making and to demonstrate the fullest possible search for practical solutions. All plans were screened for their flood control, regional development, social well-being and environmental quality performance. Plan number 78.2 was the optimum environmental quality plan and it was selected for recommendation.

3. The initial iteration of plan formulation was designed to be a rapid and innovative approach, fully responsive to local desires. A Draft Survey Report was completed in July 1973, which identified three alternative plans of flood control. Two of these plans were designed as "polar" solutions defining the full range of feasible solutions. One plan (Plan A) was a traditional structural urban flood control solution, and the other plan (Plan C) was a more naturally oriented flood control plan. A compromise solution (Plan B) was then developed as part of an intensive and extensive public involvement program. Widespread public support for this study approach and for Plan B was received. Most notable was the endorsement of the Corps' formulation approach by the Coalition for the Environment, the Ozark Chapter of the Sierra Club, the Bureau of Outdoor Recreation, the Metropolitan St. Louis Sewer District, the East-West Gateway Coordinating Council, the St. Louis County Department of Planning and the St. Louis County Council. At July 1972 price levels, Plan B would cost $60,000,000 of which the local sponsor provided assurances of non-Federal cost participation in the amount of $11,100,000. Average annual benefits for Plan B were $6,000,000 which compared to average annual costs of $4,000,000 yielded a 1.5 benefit/cost ratio.

4. The specific improvements proposed in Plan B were formulated on a system-wide comprehensive basis. Formulation decisions were based primarily on planning, engineering and environmental judgment with a great deal of public participation. No extensive detailed studies were intended, nor pursued.

5. The Plan B improvements resulting from the broad generalized approach consisted of:

a. 15 miles of gabion-lined channel improvements;

b. 7 miles of sodded-earth or natural channel improvements;

c. 60 in-channel weirs to slow the stream velocity and create small pools for recreational purposes;

d. acquisition of 537 acres in fee plus easements on an additional 266 acres of undeveloped flood plain and other open space acres to prevent unwise urbanization and to serve flood control, recreation, and other purposes according to Plan B;

e. 2 wet reservoirs to serve the purposes of flood water detention, recreation and preservation of existing open space; and

f. 14 dry reservoirs to also serve the purposes of flood water detention, recreation and preservation of existing open space.

6. A unique feature of the cycle one formulation was the tangible assessment of two traditionally intangible impacts. The following benefits approximations are worthy of note because they lead directly to the cycle two formulation.

a. Stream Sediment Control. A reduction in the sediment load to be carried by Maline Creek in the future would result as a direct impact of the proposed improvements. Traditionally this beneficial impact, though widely recognized, has not been amenable to direct tangible benefits assessment. The improvement in future stream water clarity is very similar to what happens below an impoundment

or reservoir. Therefore, for cycle one formulation purposes, stream sediment control benefits were approximated as being worth the average annual reservoir costs properly allocated to stream sediment control (i.e., allocated one-third of the total reservoir costs based on a flood control, recreation and sediment control impoundment).

b. Environmental Enhancement. This benefit category was designed to approximate the real worth of creating an attractive stream setting with pool, reservoir and open space area's plus the worth of positively preventing future unwise flood plain development. A proxy measure of this environmental enhancement worth was used because of the difficulties of direct benefit assessment. This proxy yardstick was assigned a value equal to the flood damages that would occur if the flood plain area were allowed to develop consistent with the development already located in the flood plain. In this manner, the environmental enhancement benefits recognized the value of maintaining an open space corridor and thereby precluding unwise flood plain development.

7. The initial iteration of plan formulation as described above was successful in the sense that it indicated that installation of flood control and allied purpose improvements displayed benefits in excess of costs. The time and cost necessary to prepare a more precise technical analysis and refine the plan formulation was now known to be warranted. Corps of Engineers' review of the initial plan formulation cycle directed that a second cycle of refined plan formulation be accomplished.

SECOND FORMULATION CYCLE

8. Corps of Engineers' review of the initial formulation iteration contained in the Draft Survey Report dated July 1973 resulted in deletion of the tangible assessments for some non-traditional benefit categories. Specifically, the benefit category of "stream sediment control" ($1,700,000 average annual) was deleted for lack of adequate substantiation and no known precedent. Also, the benefit category of "environmental enhancement" was judged to be less than fully substantiated and therefore was reduced from $1,100,000 to $400,000 average annual benefits. These Corps of Engineers' review changes reduced the total creditable average annual benefits to $3,600,000 which when compared to the $4,000,000 average annual costs yielded a 0.90 benefit/cost ratio (July 1972 price level). This revised information is contained in the revised draft survey report dated January 1974. Any additional information desired may be obtained by reviewing these two draft survey reports which are on file in the Urban Studies Section, St. Louis District, Corps of Engineers.

9. The second cycle of plan formulation refined the proposed improvements so as to eliminate any unjustified benefits determinations. This work concided with the Water Resource Council's publication of "Principles and Standards for Planning Water and Related Land Resources," 38FR24778-24869, 10 September 1973, which then served as the basis for the third and subsequent cycles of this study's plan formulation. Further Corps of Engineers review of the first two cycles of formulation resulted in the recognition that a valid plan of improvements did exist but must be defined and analyzed in greater detail.

Revised Formulation Criteria

10. The third cycle of formulation was undertaken to provide a level of rather detailed analysis, to conventional Corps' flood control studies and also to comply with the Water Resource Council's publication of "Principles and Standards for Planning Water and Related Land Resources" (commonly called P&S). A total of 137 additional alternatives were formulated in accordance with the P&S criteria to find the optimum solution. The paragraphs that follow summarize the work accomplished to achieve the required detail of analysis and also fulfill the P&S criteria. The third cycle of formulation concluded that plan 123 of the 140 plans studied to date (i.e., three plans in cycles one and two, plus 137 plans in cycle three) was the optimum conventional flood control, outdoor recreation and environmental quality mix.

11. Using the first two formulation cycles as a broad starting point, additional specific criteria and assumptions were established on which to base decisions during the third formulation cycle. Specific formulation criteria were established for technical, economic, environmental, and evaluation screening purposes.

12. Technical Criteria. Technical criteria are the practical guidelines that directly affect physical design features. The technical criteria are as follows:

a. The components of the recommended plan must be realistic;

b. Equal consideration will be given to nonstructural and structural approaches during plan formulation;

c. All nonstructural and/or structural measures recommended must be practical from an engineering standpoint and implementable under the specific site conditions; and

d. All nonstructural and structural measures implemented must not impede any potential future flood fight efforts. That is, they must not make flood fighting conditions more difficult.

13. Economic Criteria. Specific economic criteria were used to analyze alternative plans. The economic criteria are as follows:

a. Tangible benefits must exceed costs.

b. Each separable unit of improvement or purpose shall provide tangible benefits, plus intangible benefits, at least equal to its costs.

c. The scope of development shall be such as to provide the maximum net benefits when realistically possible and not significantly detrimental to intangible considerations.

d. There shall be no economical means, evaluated on a comparable basis, of accomplishing the same purpose or purposes which would be precluded from development if the plan were undertaken. This limitation refers only to those alternative possibilities that would be physically displaced or economically precluded from development if the project is undertaken.

e. All analyses will be based on current price levels.

f. Annual costs will be based on a 100-year period of analysis.

g. All average annual calculations will be based on the prevailing annual interest rate.

14. Environmental Criteria. Environmental criteria were established to insure that the environmental quality of the Maline Creek watershed receives equal emphasis with economic efficiency during the formulation of the alternative plans. The following criteria were used as guidelines during the formulation process:

a. The natural environment will be protected and enhanced wherever possible.

b. Should the imposition of detrimental environmental impacts be unavoidable, appropriate mitigation measures will be included.

c. The protection and enhancement of public health, safety, and social well-being will be maximized wherever realistically possible.

15. Evaluation Criteria. In order to provide a means for testing and evaluating relative plan performance, specific evaluation criteria were developed. The evaluation criteria are summarized as follows:

a. The workability and viability of the plan will be based on its acceptance by the affected publics and its accommodation of known institutional constraints (Acceptability test).

b. The technical performance of the plan and the level of contribution to the planning objectives will be specifically appraised (Effectiveness test).

c. The likelihood of the plan meeting all planning objectives as well as its contributions to the National Economic Development (NED) and Environmental Quality (EQ) accounts will be analyzed (Certainty test).

d. The capability of restoring the completed works to the without condition should public needs or values change in the future will be determined (Reversibility test).

e. The sensitivity of the plan to potential developments in the future will be analyzed (Stability test).

f. All necessary investments or other actions necessary to assure full attainment of the plan will be required (Completeness test).

g. Determine if the area encompassed by the plan is large enough to allow a full understanding of the problem and specific enough to make the plan effective (Geographic Scope test).

h. The economic viability of the plan will be determined (NED benefit-to-cost ratio test).

i. The plan's ability to achieve the planning objectives in the least cost way will be assessed (Efficiency test).

Formulation Assumptions

16. The formulation of alternative plans often depends on the perspective of the planning team regarding expected future conditions within the watershed. In order to document the formulation perspective used for this study, assumptions about future watershed conditions with and without an implemented plan

were specifically identified. The assumptions used for this study are presented in TABLE B-2. They were developed from the study results presented in APPENDIX A of this report and from the input of both the study team and local interests.

Status of Existing Plans and Improvements

17. The Corps of Engineers has constructed a levee near the mouth of Maline Creek that provides a high degree of flood protection to the city of St. Louis. This levee starts on the right bank near Riverview Drive and extends in an east-southeast direction towards the Mississippi River (mile 187.2) where it turns and continues in a southerly direction (See PLATE B-1). This levee is part of the flood protection system constructed under the authority of Public Law 256, 84th Congress, 1st Session. The system is designed to protect Reach 3 (Maline Creek to the Eads Bridge) and Reach 4 (Eads Bridge to the extension of Chippewa Street) against a 52-foot Mississippi River flood stage (Market Street gage). Details regarding the overall city of St. Louis and Vicinity project are contained within Senate Document Numbered 57, 84th Congress and "Design Memorandum No. 4, General Design," Corps of Engineers, October 1957.

18. Channel improvements have been made by local interests and are primarily located on the tributaries flowing into Maline Creek (See PLATE B-1). The Corps of Engineers has authority under Section 14 of the 1946 Flood Control Act to undertake stream bank stabilization improvements adjacent to the Meadows School located along Blackjack Creek (Tributary MD) near Chambers Road. The improvements were installed during Fiscal Year 1979.

TABLE B-2
MALINE CREEK
FORMULATION ASSUMPTIONS

FUTURE WITHOUT PROJECT CONDITION	FUTURE WITH PROJECT CONDITION
1. GENERAL: There will be no major wars, depressions, unusual inflation, or revolutions significantly affecting the watershed.	1. GENERAL: Same as for future without project condition.
2. FLOOD PROTECTION: In the absence of this project, no major flood control improvements are likely to be installed along Maline Creek.	2. FLOOD PROTECTION: The Maline Creek watershed would enjoy a significant reduction in flood damages.
3. FLOOD INSURANCE PROGRAM: All structures within the Maline Creek watershed will be covered by the Flood Insurance Program. All structures within the 100-year flood plain will be covered by federally subsidized flood insurance.	3. FLOOD INSURANCE PROGRAM: Same as for future without project condition. The with project condition will reduce the costs associated with administering the Flood Insurance Program. As a result, the flood damage prevention benefits will equal the average annual flood damages to existing structures plus the amount of Flood Insurance Administration costs reduced.
4. LAND DEVELOPMENT: No new construction will occur at or below the 100-year flood level unless it is flood-proofed to at least the 100-year flood level. The total flood insurance costs for structures and contents will be equal to the damages plus a cost to administer the Flood Insurance Program. There will be no intensification of development or locational advantage within the 100-year flood plain. The land use configur-	4. LAND DEVELOPMENT: Development will occur within flood protected areas. Intensification and locational site advantages would be credited as flood inundation reduction benefits below the previous 100-year flood elevation. No restrictions to development nor alternative flood-free site consideration would be necessary for the protected area.

TABLE B-2 (Continued)
MALINE CREEK
FORMULATION ASSUMPTIONS

FUTURE WITHOUT PROJECT CONDITION	FUTURE WITH PROJECT CONDITION
ation of the watershed will be the same as that proposed by the St. Louis County Department of Planning's future land use map. Agriculture/Vacant Land Uses outside of the 100-year frequency flood hazard area will be converted to more intense residential, industrial, and commercial uses. There will be no earthfills within the flood plain, with the purpose of elevating that land above the 100-year flood plain, which cause significant adverse economic impacts.	
5. POPULATION: The number of people residing in the Maline Creek watershed will be consistent with the projections made in Section B of this report. Because of the existing highly developed nature of the watershed and the small amount of flood-free land, the increase in population will be relatively small over the period 1980-2020. After 2020, no net increase in population will occur.	5. POPULATION: Releasing additional land for development would increase the number of people expected to reside in the watershed. Saturation would still occur by the year 2020. This development would occur in the area between the previous 100-year flood area and the improved 100-year flood area.
6. ECONOMIC DEVELOPMENT: The Maline Creek watershed will not experience significant economic development during the period 1980-2020. Development saturation will occur by 2020. The lack of flood-free land will cause a conversion of some existing agricultual/vacant lands to more intense uses in the area above the existing 100-year frequency flood hazard.	6. ECONOMIC DEVELOPMENT: The availability of additional lands would increase economic development over the levels expected with no project in place. Essentially complete development would still occur by the year 2020.

TABLE B-2 (Continued)
MALINE CREEK
FORMULATION ASSUMPTIONS

FUTURE WITHOUT PROJECT CONDITION	FUTURE WITH PROJECT CONDITION
7. ENVIRONMENT: The overall existing degraded state of the creek and its environs will continue to deteriorate. The environmental nuisance the creek creates will continue to have a significant blighting influence on the watershed.	7. ENVIRONMENT: The existing and projected degraded state of the creek and its environs would improve. Natural areas would be preserved and improved to the maximum extent possible. Residents would have increased opportunities to interact with the natural environment.
8. COMMUNITY COHESION: The threat of flash flooding and the blighting influence of the creek will continue to negatively impact community stability, pride, and cohesiveness. The large number of political jurisdictions striving to serve localized needs will not change substantially.	8. COMMUNITY COHESION: Community pride, neighborhood stability, and overall community cohesion would improve.
9. RECREATION: There will be a large unmet need for additional recreation opportunities for the inhabitants of the Maline Creek watershed. There will be no major net change in the park acreage.	9. RECREATION: The unmet needs for water-related recreation opportunities would be satisfied to the maximum extent possible.

19. The third cycle of formulation specifically identified and considered all known plausible management measures that might address the Maline Creek planning objectives. A series of screenings were then conducted to identify those management measures to be carried forward for further consideration. The first screening was conducted to determine the performance of each measure taken within the context of Maline Creek's specific planning opportunity. The evaluation criteria presented earlier were applied to each management measure as a means of analyzing their relative merits and inherent performance characteristics. The initial management measure screenings in the third cycle of formulation were conducted at the broadest possible level of detail giving consideration only to readily available information and judgment. All of the criteria previously identified were generally considered. However, since detailed economic viability and efficiency information were unavailable for this initial screening, the "acceptability" and "effectiveness" criteria tests were emphasized. The information to initially apply these two tests was readily available and, therefore, served as the basis for initial screening. When a particular management measure proved to be clearly unacceptable or physically ineffective, it was dropped from all further consideration. The remaining criteria served as the basis for making additional judgments about the surviving measures as additional data became available throughout the study. The screening technique was applied in an iterative manner with increasing levels of detail. All management measures were grouped according to whether they are primarily nonstructural or primarily structural for convenience of report display. The following paragraphs elaborate on the evaluation testing and screening of the nonstructural and structural management measures. Presented for each management measure is a discussion of the important

characteristics identified during this evaluation analysis and the conclusion reached about either carrying the measure forward, or terminating its continued consideration. TABLE B-3 presents a summary of the initial management measure screening results.

20. Nonstructural Measures. Nonstructural measures emphasize controlling the land use and types of future development which may locate within the flood plain area. These measures are generally most effective in the prevention of flood damages to development which may locate in flood hazard areas in the future. Non-structural measures have more limited effectiveness in reducing flood damages to existing development. All known nonstructural measures were considered for the Maline Creek watershed as follows: temporary evacuation; permanent evacuation; flood plain regulation; warning signs; tax concessions; floodproofing; land acquisition; wildlife management; and litter/debris control.

a. Temporary Evacuation. One way of reducing flood damages is to temporarily evacuate as many of the damageable items as possible from the flood plain area. This management measure would address the flood control objective to a very limited extent, and have essentially no impact on the other two planning objectives (outdoor recreation and environmental quality). This situation exists because of the very temporary nature of the nonstructural temporary evacuation management measure. In order for this measure to be more practical and permanent, the area where it is to be implemented must contain damageable items that are relatively mobile. In addition, sufficient time for advanced warning must be available in order to allow the property owners to take the necessary actions needed to evacuate. Advanced warning requires a relatively accurate and dependable flood warning system. The hydrologic conditions present within the Maline Creek basin are such that adequate and accurate early flood warning systems are not a

TABLE B-3
MALINE CREEK
INITIAL MANAGEMENT MEASURE EVALUATION

Criteria[1] MEASURE	ACCEPTABILITY[2]	EFFECTIVENESS[3] OBJECTIVE 1 (Flood Control)	OBJECTIVE 2 (Outdoor Recreation)	OBJECTIVE 3 (Environmental Quality)	CER-TAINTY[4]	STABIL-ITY[5]	REVERS-IBIL-ITY[6]	GEO-GRAPHIC SCOPE[7]	COM-PLETE-NESS	ECONOMIC VIA-BIL-ITY	EFFI-CIENCY
Non-Structural Measures											
Temporary Evacuation	Acceptable	Very Little	None	None	Uncertain	Unstable	Reversible	Sufficient	N/A[8]	N/Q[9]	N/Q[9]
Permanent Relocation	Acceptable[10]	Significant	Signigicant	Significant	Certain	Unstable	Reversible	Sufficient	N/A	N/Q	N/Q
Flood plain Regulations	Acceptable	Significant	Significant	Significant	Certain	Unstable	Reversible	Insufficient	N/A	N/Q	N/Q
Warning Signs	Acceptable	Very Little	None	None	Uncertain	Unstable	Reversible	Insufficient	N/A	N/Q	N/Q
Tax Concessions	Unacceptable	Partial	Partial	Partial	Uncertain	Stable	Reversible	Insufficient	N/A	N/Q	N/Q
Flood Proofing	Acceptable	Significant	None	None	Certain	Stable	Irreversible	Sufficient	N/A	N/Q	N/Q
Land Acquisition	Acceptable	Very Little	Significant	Significant	Certain	Stable	Reversible	Sufficient	N/A	N/Q	N/Q
Wildlife Management	Acceptable	Very Little	Partial	Significant	Certain	Stable	Reversible	Sufficient	N/A	N/Q	N/Q
Litter/Debris Control	Acceptable	Partial	Very Little	Significant	Certain	Stable	Reversible	Sufficient	N/A	N/Q	N/Q
Structural Measures											
Levees and Floodwalls	Unacceptable	Significant	Partial	None	Certain	Stable	Irreversible	Sufficient	N/A	N/Q	N/Q
Detention Basins	Acceptable	Significant	Significant	Significant	Certain	Unstable	Reversible	Sufficient	N/A	N/Q	N/Q

TABLE B-3 (Continued)
MALINE CREEK
INITIAL MANAGEMENT MEASURE EVALUATION

Criteria[1] MEASURE	ACCEPTABILITY[2]	EFFECTIVENESS[3] OBJECTIVE 1 (Flood Control)	OBJECTIVE 2 (Outdoor Recreation)	OBJECTIVE 3 (Environmental Quality)	CERTAINTY[4]	STABILITY[5]	REVERSIBILITY[6]	GEOGRAPHIC SCOPE[7]	COMPLETENESS	ECONOMIC VIABILITY	EFFICIENCY
Structural Measures											
Channel Modifications	Acceptable	Significant	Partial	Significant	Cetain	Stable	Irreversible	Sufficient	N/A	N/Q	N/Q
Diversions	Unacceptable	Significant	Partial	Partial	Certain	Stable	Irreversible	Sufficient	N/A	N/Q	N/Q
Watershed Treatment	Acceptable	Very Little	Significant	Significant	Uncertain	Unstable	Reversible	Sufficient	N/A	N/Q	N/Q
Aquatic Habitat Structures	Acceptable	None	Significant	Significant	Certain	Stable	Irreversible	Sufficient	N/A	N/Q	N/Q

FOOTNOTES:

[1]Criteria are defined in the text. Please recognize that the information in Table B-3 reflects the concerns addressed during the initial cycles of management measure analysis accomplished in 1974. The dynamic nature of urban areas and Federal urban planning is well demonstrated by observing the changes in management measure evaluation as discussed in the final formulation cycle under "Structural and Nonstructural Aspects of the Recommended Plan."
[2]Either acceptable or unacceptable.
[3]Either significant, partial, very little, or none.
[4]Either certain or uncertain.
[5]Either stable or unstable.
[6]Either reversible or irreversible.
[7]Either sufficient or insufficient.
[8]Not applicable.
[9]Not quantified.
[10]Only if used in limited manner.

realistic probability. The very rapid rate of runoff within the Maline Creek basin causes this stream to be classified as a "flash" flooding stream. In addition, most of the damageable property along Maline Creek is relatively immobile. Some consideration was also given to the fact that temporary evacuation does not address the significant disruption to family units and commercial industrial services which occur when temporary evacuation is used as a significant management measure. Therefore, temporary evacuation as a major management measure for Maline Creek is deemed essentially ineffective. The local sponsor for this study verified this conclusion based on their extensive local experience. Consequently, temporary evacuation has been eliminated from all further consideration for this study.

b. Permanent Relocation. This measure consists of the wholesale physical removal of all damageable property from within the boundaries of the flood plain and relocating it elsewhere. This measure would contribute to all of the planning objectives, assuming the vacated flood plain area would be devoted to uses which are not subject to significant damage nor environmentally disruptive. The disadvantages associated with this measure within the setting of the Maline Creek watershed are significant when the "technical criteria" and "evaluation criteria" are considered in more detail. For example, permanent relocation would require the removal of 2,527 homes plus 56 commercial establishments to protect against the 100-year flood. The experience of Corps and other Federal and non-Federal efforts on permanent relocation in other areas of the United States indicates a cost of hundreds of millions of dollars. The first two cycles of formulation clearly indicated a much more cost efficient alternative could be found with use of a more limited relocation feature. Implementing this management measure would be a very time-consuming, costly, and legally complicated procedure. Moreover, the social disruption caused by relocation of such a

significant portion of the existing community would be very difficult and in itself serves as a major deterrent to the implementation to this management measure. The overall conclusion reached regarding this management measure is that the extensive use of permanent relocation is a socially unacceptable and economically undesirable solution to address this study's planning objectives. From an environmental viewpoint, wholesale relocation impacts fully depend on the environmental worth of the area to be consumed by the relocated development versus the uses of the vacated area. Wholesale relocation seems to intensify continued urban sprawl which generates a large train of poor environmental effects. Therefore, this management measure has been dismissed from further consideration with only a more limited use of relocation reserved for those structures basically located in the immediate floodway area. The floodway area is defined as being that portion of the flood plain immediately bordering the stream channel that is needed to pass the base flood (i.e., the 1 percent chance flood), without raising that flood elevation more than 1 foot above existing conditions.

c. Flood Plain Regulations. Falling within this category of nonstructural regulatory measures are flood plain zoning, subdivision regulations, and building codes. Each of these measures is normally implemented by local ordinances. Local ordinances may regulate the type, location, amount, and/or nature of development allowed within flood plain areas. Specifically, flood plain zoning controls the type, amount, and location of flood plain development; subdivision regulations primarily control how land is subdivided for development; while building codes essentially set minimum construction standards for individual structures. The ability of each of these management measures to address the planning objectives and the conclusions drawn from these considerations are discussed

individually for each of the regulatory measures considered. Flood plain zoning could eventually contribute to all of the Maline Creek planning objectives. Flood plain zoning could be utilized to assure compatible land uses within flood plain areas. Compatible land uses in flood plain areas include such uses as parks, scenic areas, wildlife refuges, golf courses, and off-street parking. Land uses of this compatible type would reduce the risk of sustaining future flood damages and would contribute to the recreational opportunities as well as enhancing the aesthetic and environmental qualities of the Maline Creek watershed. Subdivision regulations would primarily address the flood control objective, while building codes would only partially address the outdoor recreation and environmental quality objectives. From the onset of this study, flood plain regulation measures were assumed to be an integral component of the watershed's future without project conditions. It is considered that implementation of any or all of these regulatory measures by local interests will be fully consistent with the final recommendations of this study. This aspect of the Maline Creek study approach has been adopted because the National Flood Insurance Program, created in 1968, may eventually require all participating communities to adopt and enforce flood plain regulatory measures. This study has assumed that all jurisdictions in the watershed will eventually enroll and participate in the National Flood Insurance Program. Flood plain regulatory management measures are considered to be an integral part of all future water resources plans for the Maline Creek watershed.

d. Warning Signs. As a means of alerting future flood plain development to the flood hazard, signs could be erected in prominent locations to identify the flood hazard. Because the success of this measure depends largely upon voluntary compliance, it is considered to be relatively unassured. Even if implemented within the Maline Creek watershed, in the view of the local interests and the Guidance Committee, this measure would have very little impact on satisfying

the planning objectives. Therefore, this management measure was eliminated from further consideration during this study.

e. Tax Concessions. Changes in the property tax rates within the flood plain could be implemented to encourage the development of compatible flood plain land uses. This measure is considered to have very minor impact on all of the planning objectives. Due to the large number of independent taxing bodies existing within the Maline Creek watershed, this measure would be extremely difficult to effectively implement. Therefore, it was dropped from further consideration for this study.

f. Flood Proofing. Flood proofing alters the existing structural design or physical setting of damageable properties in a manner to reduce flood damages. Typical flood proofing techniques consist of waterproofing basements, elevating property, structure underpinning, utility and road protection, closures for drainage and other pipe openings, structural anchoring systems, individual ditches around existing structures, and small levees. The principal function of flood proofing would be to address the flood control objectives. Outdoor recreation and environmental quality objectives would not be significantly addressed by this measure. A serious restraint to flood proofing is that it is most useful in areas where isolated individual structures are susceptible to frequent low-level flooding. Since this type flood problem exists to some limited extent in the Maline Creek area, flood proofing was carried forward for further consideration.

g. Land Acquisition. The most positive way of preserving the existing undeveloped land area in the Maline Creek watershed is to purchase it and place it into public ownership. This measure could address the outdoor recreation objective should those public lands then be used for recreational pursuits. The environmental

enhancement objective could also be addressed if those public lands were managed in such a manner to protect fish and wildlife habitat and help in noise abatement. Preservation of undeveloped areas may also contribute to the flood control objective through a relatively minor reduction in stormwater runoff. Since this measure is effective in addressing two objectives it was carried forward for further consideration.

h. Wildlife Management. This measure involves the manipulation of lands and vegetation so as to benefit desirable wildlife species. Two types of wildlife management were considered. The first would be used on project lands, and the second would be proposed and encouraged for use by private landowners. Wildlife management would contribute significantly to the environmental enhancement objective by enhancing fish and wildlife habitat and helping to reduce adverse noise levels. It would also significantly contribute to outdoor recreation objective by increasing the opportunity for such activities as nature hiking and birdwatching. Wildlife management practices will contribute to the flood control objective in only a minor way by the possibility of decreasing stormwater runoff. For these reasons, the wildlife management measure was carried forward for further consideration.

i. Litter/Debris Control. A litter and debris control program would be effective to solve the problem of litter/debris being dumped in and along Maline Creek. This measure would have a partial effect in addressing the flood control objective by removing obstructions to stream flow. Very little impact would be anticipated with regard to the outdoor recreation objective. This measure would have a significant impact on the environmental quality objective by improving the aesthetic qualities of the watershed as well as removing possible sources of safety and health problems. For these reasons, litter/debris control was carried forward for further consideration.

21. Structural Measures. Structural measures provide a positive means for preventing or reducing flood damages, stream bank erosion, and improving the aquatic habitat diversity. They are very effective for addressing both existing as well as future water and related land resource problems and needs. Their forte is their immediate positive impact upon solving existing problems. The structural measures specifically considered for the Maline Creek watershed are: levees and floodwalls; detention basins; channel improvements; channel diversions; watershed treatment; and artificial aquatic habitat structures.

a. Levees and Floodwalls. These measures control flooding by imposing a physical barrier between damageable property and flood waters. The preliminary analysis of these measures concluded that they would be technically effective since they would significantly address Objective 1 (flood control). Levees would also be effective to a lesser extent on Objective 2 (outdoor recreation) if they were utilized as part of a linear trailways system. However, the continuous and extensive levee/floodwall system needed in order to be effective would require numerous relocations, induce interior drainage problems, and be a potentially aesthetic nuisance within such a highly urbanized area. It was also recognized that a levee/floodwall system may have some positive environmental impact by providing an acoustical barrier. The decision was made not to carry a major levee/floodwall system forward as a viable alternative. Instead, smaller levees that could provide protection to smaller groups of structures would be considered under the flood proofing alternative.

b. Detention Basins. This measure functions to regulate flood discharges by temporarily storing potentially damaging flows until after the threat of immediate downstream flooding has passed. The detention basin would then empty at a non-damaging rate.

Besides contributing significantly to the flood control objective, detention basins can also provide recreation opportunities during normal flow conditions. Enhancement of the aesthetic and the environmental quality may occur by reducing sediment loads carried by the stream and by providing open space. A detention basin with some storage used as a fish pond would contribute significantly to the outdoor recreation objective. Because detention basins can make significant positive contributions to all of the objectives, this measure was carried forward for further consideration.

c. Channel Modification. Another structural approach is to improve the channel's conveyance characteristics so that it can discharge larger volumes of water per unit of time, thereby reducing flood stages. Channel modifications usually involve methods such as the following:

(1) Lining the channel with hydraulically efficient materials for the dual purposes of reducing the water depth and increasing the conveyance capacity;

(2) Widening and/or deepening the channel to increase its flow capacity;

(3) Removing flow-inhibiting bends and curves in the waterway (channel straightening); and

(4) Removing or modifying obstructions from the channel such as brush, trees, culverts, bridges, and man-produced debris.

Because of this measure's ability to reduce flood stages, it would be highly responsive to Objective 1 (flood control). As flood stages are reduced and flood plain boundaries are brought closer to the stream, more land would become available outside the flood

hazard area for urban or suburban use. With proper planning, Objective 2 (outdoor recreation) could be partially addressed if lands remaining after construction were utilized for recreation purposes. Since it is expected that an aesthetically degraded state of the stream will exist under the future without project condition, channel modifications could greatly improve the physical appearance of the stream, as well as address the erosion problem. This measure, then, would also partially address Objective 3 (environmental enhancement). An adverse impact of this measure is the increased public safety hazard which results from increased stream flow velocities. As a result of the above considerations, channel modifications were carried forward as a viable alternative. It is recognized that during construction, there may be unavoidable negative impacts since disturbances caused by construction activities may accelerate erosion at the construction site, remove some vegetation, disrupt aquatic and wildlife habitats, and increase sediment loads during the period of construction.

d. Diversion. This measure would essentially reroute all or portions of the flood waters away from damage centers. Reducing the flood risk in this manner would not only respond significantly to Objective 1 (flood control), but it could also present opportunities for developing recreation areas on the lands previously occupied by the channel. Environmental quality impacts would be directly dependent on the specific diversion route and the use made of the old stream channel area. However, use of this measure within the setting of Maline Creek is both physically impractical and socially undesirable due to the highly urbanized nature of the watershed. No reasonable alternative channel sites were found during the preliminary screening that would avoid the need for extensive property and utility relocations. As a result, this measure was dropped from further consideration.

e. Watershed Treatment. Watershed treatment consists of methods designed to improve the ability of the soil to absorb and retain excessive rainfall. In rural areas, the techniques used include contour strip cropping, crop rotation, terrace construction, and selective reforestation. In urban areas, the techniques used are primarily planting or reforestation, and construction measures designed to catch and temporarily retain rainfall. If implemented, this measure would contribute to each planning objective. However, watershed treatment was found to have little applicability due to its very limited impact on flood occurrences and the lack of centralized control over land use and developmental construction techniques. As a result, this measure was eliminated from further consideration.

f. Aquatic Habitat Structures. This measure consists of constructing instream aquatic habitat pools and sanctuaries. Creation of these instream aquatic habitat pools is usually accomplished by placing staggered rock filled "gabion" wire baskets in an appropriate manner at selected stream locations. This measure would contribute significantly to Objective 3 (environmental enhancement) by providing sanctuaries, feeding and nesting areas for fish and aquatic organisms. Objective 2 (outdoor recreation) would be addressed by increasing the opportunities for fishing and wading. This measure would make no contributions to Objective 1 (flood control). Because of its significant contributions to Objectives 2 and 3, this measure was carried forward for further consideration.

Single Objective Alternatives

22. After the initial third cycle screening iterations to identify viable management measures was completed, attention turned to developing an array of plans to specifically address each of the

planning objectives independent of one another. This formulation technique was adopted in order that each planning objective would be fully and equally considered. Specific plan performance criteria were identified within each independent planning objective, to serve as indicators of each plan's relative success. All the surviving management measures were assessed, evaluated and screened to help create better plan performance. Specific screening criteria were then selected as an aid to identifying the better management measures and their single-purpose plans. The overall objective of this formulation effort was to clearly determine that the more refined multi-objective studies to be pursued in later formulation were warranted and based on a firm foundation of realistic and effective single-purpose analysis.

23. Alternatives for Addressing Planning Objective 1 (Flood Control). It was apparent from the information generated to this point that a significant flood damage reduction potential exists in the Maline Creek watershed and that structural measures would very likely provide the primary means to realize this potential. It was also apparent that any widespread implementation of these measures would alter the hydrologic responses of the drainage system. In order to provide a timely, accurate, and complete estimate of the hydraulic, hydrologic, and economic impacts of proposed measures upon the system various computer model assistance was used. The hydraulic computer model (HEC-2), hydrologic model (HEC-1), and economic model (SLD Urban Damage Program plus HEC-1) were utilized in conjunction with yet one other computer model (referred to hereafter as the "hydro-econ model" (see APPENDIXES D and H). As discussed earlier, the three basic measures identified to be carried forward for further consideration that would address the flood control planning objective were: detention basins; flood proofing; and channel modifications. Initial work focused on identifying the independent performance characteristics of each surviving management

measure on a first added basis. During this analysis, extensive flood proofing was screened out as a system-wide alternative for reasons discussed later in this section. During the next phase of work, plans were prepared by combining the better detention basin and channel modification performance components into multi-measure alternatives to address the flood control planning objective. A measure's component is defined as its scale and/or geographic location of application. Measures or their individual components were carried forward for further consideration if they were clearly economically feasible, effective for addressing the planning objective, or beneficial to social well-being. The alternatives for addressing the flood control objectives are summarized in the subparagraphs that follow.

a. Detention Basins. Once it was apparent that detention basins were potentially effective measures, all alternative basin sites within the watershed area were identified and canvassed. Only sites that would utilize existing open space and had suitable topographic features were considered. A total of 17 sites were identified using this criteria. These sites are shown on PLATE B-2. Closer inspection of these 17 detention sites revealed that one site (MA-1) had significant physical design problems. Therefore, detention site MA-1 was eliminated from further consideration. In addition, during the course of this study, site MD2-1 was lost to urban development thereby eliminating it from further practical consideration as well. Each detention dam was designed to be an earth fill structure with a single low-level outlet, similar to a highway culvert. An unregulated concrete spillway, located approximately 5 feet below the top of the fill, was sized to safely pass the probable maximum flood. Three dam heights were estimated at each remaining site ranging from the largest feasible height, constrained by topography and/or encroachment by existing development to the minimum height judged to

have a significant hydrologic impact. The medium height was estimated to lie between the two extremes, thus allowing a potential for optimization at a later stage of project design. The optimum low level outlet size was judged to lie in the range from 2 to 8 feet in diameter and reinforced concrete pipe selected as the most likely material. Each of the 9 discreet outlet sizes (number one being smallest and number nine largest) could be combined with each possible dam height for a total of 27 alternative dam designs at each site. Each site in its basic configuration was assumed to be for dry detention (i.e., with no permanent pool), although net storage could be contemplated, and modeled by slight modifications to the computer data. Each site was designated a routing reach in the HEC-1 hydrologic model, with no routing specified for the without project condition. Since the hydrologic impacts of the detention basin could now be simulated (HEC-1) by specifying the storage versus discharge relationship for each site and size combination, a full set of storage-discharge curves were developed for each site using routing curves developed by a culvert hydraulics computer program, the broad-crested weir flow equation, and specific elevation-storage curves for each site. The performance of the remaining 15 sites was quantified by computing the average annual benefit at each site generated as a "first-added" system component using the "hydro-econ model." In order to test the performance sensitivity of different sizes of dam heights and low-level outlets, three configurations were chosen and tested at each site. TABLE B-4 presents a summary of the information comparing these sites, while TABLE B-5 compares the average annual benefits and estimated average annual costs for each site and configuration tested. As can be seen from the results, 8 sites (M-27, M-22, MH1, MF1, MF2, MD1, MD2-2, and MD1-1) generate benefit-to-cost ratios above unity from this first added test. These sites were, therefore, identified as prime candidates for inclusion in the flood control system plan formulation discussed later.

TABLE B-4
MALINE CREEK
SELECTED DETENTION BASIN INFORMATION

Site	Drainage Area (Acres)	Maximum Dam Elev. (MSL)	Maximum Pool Area (Acres)	Storage (Acre-Feet)
M27	525	590	63	942
M22	101	580	16	215
MH1	123	570	20	277
MF1	300	570	30	514
MF2	220	530	6	56
M13	353	510	56	813
MD1	422	510	10	52
MD2-2	198	560	30	407
MD2	83	515	15	160
MD1-1	422	550	52	786
MD1-2	118	545	17	233
MC1	113	520	23	220
MC2	213	505	49	576
MB1	208	505	47	580
MB2	117	480	18	193

TABLE B-5
MALINE CREEK
DETENTION BASIN PERFORMANCE ANALYSIS

Site	Configuration	Average Annual Benefits ($1000)	Average1/ Annual Costs ($1000)	BCR@ 6-3/8%2/
*M27	Lg. dam, #1 outlet	186.4	89.8	2.08
	Lg. dam, #3 outlet	186.8	92.6	2.02
	Med. dam, #1 outlet	172.1	51.7	3.33
*M22	Same	81.1	50.8	1.60
		62.7	53.0	1.18
		80.7	35.8	2.25
*MH1	Same	100.7	43.8	2.30
		39.9	46.3	0.86
		99.9	35.1	2.85
*MF1	Same	75.6	67.1	1.13
		50.1	69.3	0.72
		71.7	46.3	1.55
*MF2	Same	70.6	53.3	1.32
		19.3	54.6	0.35
		49.6	50.8	0.98
M13	Same	66.0	87.5	0.75
		49.1	90.1	0.54
		50.7	53.7	0.94
*MD1	Same	28.9	60.4	0.48
		65.9	60.7	1.09
		20.5	57.2	0.36
*MD2-2	Same	61.7	51.4	1.20
		48.7	54.6	0.89
		57.5	37.4	1.54
MD2	Same	19.0	40.9	0.46
		1.8	43.1	0.04
		18.7	29.1	0.64
*MD1-1	Same	82.3	89.1	0.92
		67.0	91.4	0.73
		77.4	58.1	1.33

TABLE B-5 (Continued)

MALINE CREEK

DETENTION BASIN PERFORMANCE ANALYSIS

Site	Configuration	Average Annual Benefits ($1000)	Average[1/] Annual Costs ($1000)	BCR@ 6-3/8%[2/]
MD1-2	Same	25.5	61.1	0.42
		15.8	62.3	0.25
		25.2	37.4	0.67
MC1	Same	11.8	42.2	0.28
		6.9	44.4	0.16
		11.6	34.5	0.34
MC2	Same	31.4	57.8	0.54
		28.1	59.1	0.48
		22.0	34.2	0.64
MB1	Same	10.1	65.5	0.15
		6.7	67.7	0.10
		8.8	40.1	0.22
MB2	Same	8.3	34.8	0.24
		3.3	36.1	0.09
		7.9	26.2	0.30

1/ Does not include costs for O&M and major replacement.

2/ Initial analysis based on the then current interest rate of 6-3/8 percent.

* Has at least one dam/outlet configuration that is justified.

b. Flood Proofing. During the initial preparation of alternatives to reduce economic losses and social disruptions due to flooding along Maline Creek, studies of the cost to install various flood proofing devices were initiated. As data regarding the economic efficiency of flood proofing and alternative flood protective measures (i.e., detention and channel improvements) became available, it became apparent that flood control measures other than flood proofing were generally more efficient. Another flood proofing characteristic identified and considered was its probable lack of practical implementability in the Maline Creek watershed. Actual installation of this management measure would be dependent upon the essentially voluntary compliance of the homeowner (and commercial-industrial property owner). Flood proofing of the mobile type (i.e., emergency doors and temporary window well covers) would require the assumption that property owners were quickly available to install the temporary measures on very short notice. Considerations of local property owner financial capability to participate (assuming first their desire to participate), plus the potentially complicated legal difficulties, including modified building code requirements, insurance requirements, and potential safety problems, were among the many reasons why flood proofing as an independent area-wide solution was dropped from further consideration.

c. Channel modifications. A comprehensive set of channel improvement alternatives were developed using a consistent set of assumptions as summarized below:

(1) The grade (elevation of the channel flowline) and alinement (plan view location) of the improved channel would be unchanged for hydraulic computations from that presently existing. For more detailed design, the alinement proposed in "Maline Creek Storm Water Study - MO.P-2G" by the Metropolitan St. Louis Sewer

District, would be utilized whenever possible due to right-of-way considerations.

(2) A channel improvement would be of a single, prismatic size and shape throughout a reach.

(3) Transition sections would not be utilized between improved reaches for formulation planning.

(4) All reaches previously defined (APPENDIX A) are candidates for modification and every alternative applies in every reach.

(5) The type of surface or lining of the channel will have a distinct impact upon the system hydrology. Three levels of roughness were assumed for particular lining types:

(a) Grass-lined Earth - Mannings "N" = .046

(b) Rock-filled Gabions - Mannings "N" = .036

(c) Smooth Concrete - Mannings "N" = .013

(6) Two channel shapes were assumed to cover the range of possibilities:

(a) Trapezoidal with a variable bottom width and three horizontal to one vertical side slopes.

(b) U-frame channels with near-vertical side slopes and variable bottom widths.

(7) A range of three sizes of each type-shape combination was assumed to be adequate to contain the expected optimum size:

(a) Small - A channel of essentially the same flow area as the existing channel at each location.

(b) Large - A channel of the largest feasible size constrained by right-of-way restrictions or the anticipated flow quantities.

(c) Medium - A channel size approximately halfway between small and large.

24. Because of the numerous alternative channel modification measures being considered for each reach, a two-step screening process was employed in order to identify the economically viable measures and reaches to be carried forward. The first screening compared the average annual cost of each channel measure within a reach to the average annual damages for that same reach. If the annual damages exceeded the annual costs, the reach and measure were carried forward to the second screening. TABLE B-6 presents a summary of the results of this initial screening.

25. A second screening was then conducted. A single-measure hydraulic model (HEC-2) of the entire system was developed for each of the 12 channel alternatives size-type combinations. Using all of the components of the hydro-econ model, the water surface profiles for the modified system were developed, discharge-damage curves were computed by the Urban Damage Program, and the net benefits for each measure and each reach were calculated by HEC-1. In addition, the storage-discharge curves for each reach/alternative from HEC-2 and the discharge-damage functions from the Urban Damage Program were

TABLE B-6
MALINE CREEK
FIRST SCREENING SUMMARY - CHANNEL MODIFICATIONS

Reach	Average Annual Damages[1/] ($1000)	Feasible Channel Measures[2/]	Conclusions
M1	35.0	Small earth only	Carry forward
M2	24.1	None	Drop reach
M3	61.1	Small and medium earth only	Carry forward
M4	61.7	Any size earth and gabion	Carry forward
M5	539.8	All	Carry forward
M6	179.0	Any size earth and gabion	Carry forward
M7	6.4	None	Drop reach
M8	358.5	Any earth and gabion; small and medium concrete & U-frame	Carry forward
M9	89.8	Small gabion only	Carry forward
M10	199.0	Any size earth and gabion	Carry forward
M11	285.1	All	Carry forward
M12	559.3	All	Carry forward
M13	84.8	Small and medium earth only	Carry forward
M14	64.1	Small and medium earth only	Carry forward
M15	18.1	None	Drop reach
M16	118.8	Any gabion plus small earth	Carry forward
MA	80.6	Any size earth	Carry forward
MB	20.1	None	Drop reach
MC	110.4	Any size earth	Carry forward
MD1	22.3	None	Drop reach
MD2	124.3	Any earth and gabion plus small U-frame	Carry forward
MD3	46.4	Small and medium earth	Carry forward
MD4	31.7	Small earth only	Carry forward
MD5	43.0	Any earth and gabion	Carry forward
MD6	12.7	Small earth only	Carry forward
MD1-1	3.7	None	Drop reach
MD1-2	49.9	None	Drop reach
MD1-3	0	None	Drop reach
ME	0	None	Drop reach
MF1	3.0	None	Drop reach
MF2	5.2	None	Drop reach
MG1	16.1	Small earth only	Carry forward
MG2	481.9	All	Carry forward
MH	32.3	Small and medium earth only	Carry forward

1/ Inundation damages only. Assumed to be equal to maximum average annual benefits for this screening.

2/ Identifies channel measures that have average annual costs equal to or less than average annual damages. Because of the large volume of data, the cost information is not presented here. This information is on file with the St. Louis District, Corps of Engineers.

stored in computer files for further use in the formulation process. This second screening then compared the average annual costs of the surviving channel measures with their respective calculated average annual benefits. All reaches having at least one measure with positive net benefits were carried forward for further study. Measures in the viable reaches that had negative net benefits were eliminated from further consideration for initial plan formulation. TABLE B-7 presents a summary of the second screening. It should be noted that later phases of plan formulation were not constrained to only the economically viable measures established by this two-step screening process. As intangible considerations played an increasingly important role in plan formulation, consideration was again given to all possible channel modification management measures and their respective intangible performance. With respect to bridge and culvert modifications, the with and without bridge modification conditions were analyzed. Each of the bridges located at the terminus of a reach was assumed to be modified so that no appreciable swellhead was produced. Since the location of the bridges was a principal criteria in the reach selection process, only a few isolated small bridges were not located at the terminus of a reach. These minor structures, which can be located on the water surface profiles in APPENDIX D, were classified as "embedded" and could not be isolated for analysis. The presence or absence of bridge swellheads has a potential impact on channel improvements in the reach upstream of the bridges as well as on the hydrographs and peak discharges below the bridge. Thirteen sets of hydraulic model data (HEC-2) were developed for the bridge modification alternative: one set with only the bridges modified, and 12 sets with all bridges and each of the 12 channel modifications. The hydro-econ model was employed. Examination of the economic impacts of these 13 single-measure plans revealed that the costs of major bridge modifications exceeded the extra benefits they generated thus eliminating major bridge modification from

TABLE B-7

MALINE CREEK

SECOND SCREENING SUMMARY - CHANNEL MODIFICATIONS

Reach[1/]	Feasible Channel Measures[2/]	Conclusions
M1	None	Drop reach
M3	Small earth only	Carry forward
M4	Any earth and gabion	Carry forward
M5	All	Carry forward
M6	Any earth or gabion except large earth	Carry forward
M8	All earth, gabion; small and medium concrete and U-frame	Carry forward
M9	None	Drop reach
M10	Any earth or gabion	Carry forward
M11	Any earth, gabion; small concrete, U-frame; medium concrete	Carry forward
M12	Any earth, gabion; small and medium concrete, or U-frame	Carry forward
M13	Small or medium earth	Carry forward
M14	Small or medium earth	Carry forward
M16	None	Drop reach
MA	None	Drop reach
MC	Any earth	Carry forward
MD2	Any earth or gabion	Carry forward
MD3	Small and medium earth	Carry forward
MD4	Small earth	Carry forward
MD5	Small earth	Carry forward
MD6	None	Drop reach
MG1	None	Drop reach
MG2	Any earth, U-frame; medium and large gabion; small and medium concrete	Carry forward
MH	Small earth	Carry forward

1/ Includes only those reaches remaining after first screening.

2/ Identifies channel measures that have average annual costs equal to or less than computed average annual benefits for each measure.

further consideration. Embedded bridge modifications were carried forward as an integral part of the channel modification for the reach in which they are located.

26. Flood Control System Formulation (First Iteration). The completion of the above formulation effort marked the end of the use of the hydraulic model (HEC-2) and the Urban Damage Program. From the information these two models generated, a computer data bank was created for each measure/reach and contained the storage-discharge and damage-discharge characteristics of each measure/reach for all channel bridge and detention measures. Due to the sub-critical flow nature of the system, each modification was assumed to affect only the reach in which the improvement was implemented and through modified hydrographs, all reaches downstream. All subsequent plan formulation was conducted using only this data bank and the hydrologic model (HEC-1) operated in the "multi-plan" mode. The "multi-plan" hydro-econ model permits quick, accurate economic computations based upon complete and pertinent hydrologic and hydraulic data for any combination of modifications modeled. With this multi-plan model developed, the next step taken was to identify alternative mixes of the independently justified measures and then test the flood control system performance. To reach this end, two basic flood control system plans were initially formulated using the detention sites in conjunction with the channel measures which survived the second screening iteration described above. As discussed earlier, flood proofing was screened out from further system-wide consideration.

27. The first plan formulated (FC1) was assembled using those remaining measures that generated the most net benefits during the individual measure screenings. The second plan (FC2) was assembled with a view towards identifying the mix of measures that generated

the fewest system damages remaining (i.e., most system benefits). TABLE B-8 identifies the components of each plan (FC1 and FC2) by reach and detention site.

28. These two plans were then processed by the multi-plan model in order to compute average annual systems benefits. Concurrently, the detention and channel modification subsystems of FC1 and FC2 were analyzed separately. This subsystem calculation of benefits was pursued in order to identify system component performance. TABLE B-9 displays a summary of information learned during this system and subsystem iteration of flood control system formulation.

29. Flood Control System Formulation (Second Iteration). After the economic formulation criteria were addressed during the first iteration, attention turned to the consideration of the design formulation criteria. An additional plan was assembled during this second iteration with a view towards improving damage reduction effectiveness, while maintaining the physical compatibility of the improvements from reach to reach. This was accomplished by selecting measure sizes deemed physically compatible with each reach's upstream and downstream counterpart and placing improvements in some reaches previously eliminated for economic reasons so that physical design continuity and higher damage reduction could be accomplished. This plan, Plan FC3, was assembled using Plan FC2 as a base. TABLE B-10 identifies the components of Plan FC3. TABLE B-11 presents a summary of the economic performance of this plan. The average annual inundation reduction benefits displayed in this table were again calculated using the multi-plan model.

30. Alternatives for Addressing Planning Objective 2 (Outdoor Recreation). The initial formulation of alternative recreation plans was pursued, first on a single-objective basis, and then on a combined systems basis similar to the planning approach described

TABLE B-8
MALINE CREEK
FIRST ITERATION PLANS AND COMPONENTS

Reach Location/ Detention Site	Plan FC1 Components	Plan FC2 Components
M3	Small earth	Small earth
M4	Small earth	Large gabion
M5	Small earth	Large U-frame
M6	Small earth	Large gabion
M8	Small earth	Small concrete
M10	Small earth	Large gabion
M11	Small earth	Small U-frame
M12	Medium gabion	Small U-frame
M13	Small earth	Medium earth
M14	Small earth	Medium earth
MC	Large earth	Large earth
MD2	Small earth	Large gabion
MD3	Small earth	Medium earth
MD4	Small earth	Small earth
MD5	Small earth	Small earth
MG2	Large gabion	Medium U-frame
MH	Small earth	Small earth
Detention M27	Medium dam, small outlet	Large dam, medium outlet
Detention M22	Medium dam, small outlet	Large dam, small outlet
Detention MH1	Medium dam, small outlet	Large dam, small outlet
Detention MF1	Medium dam, small outlet	Large dam, small outlet
Detention MF2	Large dam, small outlet	Large dam, small outlet
Detention MD1	Large dam, medium outlet	Large dam, medium outlet
Detention MD2-2	Medium dam, small outlet	Large dam, small outlet
Detention MD1-1	Medium dam, small outlet	Medium dam, small outlet

TABLE B-9
MALINE CREEK
SUMMARY OF FIRST ITERATION SYSTEM PLANS

Plan	Ave. Annual Damages Future Without ($1000)	Ave.1/ Annual Benefits ($1000)	Ave. Annual Damages Remaining ($1000)	Percent Damage Reduction	Ave.2/ Annual Costs ($1000)	Ave. Annual Net Benefits ($1000)	BCR3/@ 6-3/8%
FC1	3768.3	2684.7	1083.6	71.2	1049.8	1634.9	2.56
FC2	3768.3	2859.3	909.0	75.9	2581.0	278.3	1.10
FC1 Detention	3768.3	848.5	2919.8	22.5	378.5	470.0	2.24
FC2 Detention	3768.3	865.3	2903.0	23.0	477.8	387.5	1.81
FC1 Chan. Mod.	3768.3	2171.9	1596.4	57.6	671.3	1500.6	3.24
FC2 Chan. Mod.	3768.3	2428.7	1338.6	64.5	2103.0	325.7	1.15

1/Inundation reduction only.

2/Does not include O&M or major replacement. Includes 50% contingencies.

3/Initial analysis accomplished based on the then current interest rate of 6-3/8 percent.

TABLE B-10

MALINE CREEK

PLAN FC3 COMPONENTS

Reach	Plan FC3 Components[1/]
M1	Medium gabion
M2	Medium gabion
M3	Medium gabion
M4	Small gabion
M5	Large gabion
M6	Small earth
M7	Small earth
M8	Small earth
M9	Small earth
M10	Medium gabion
M11	Large gabion
M12	Large gabion
M13	Small earth
M14	Small earth
MC	Medium gabion
MD1	Small earth
MD2	Medium gabion
MD3	Small gabion
MD4	Small earth
MD5	Small gabion
MG2	Large gabion
MH	Medium earth

1/The Plan FC2 detention system was retained for this plan.

TABLE B-11
MALINE CREEK
SUMMARY PLAN FC3 PERFORMANCE

Average Annual Damages Future Without ($1000)	Average Annual[1] Benefits ($1000)	Average Annual Damages Remaining ($1000)	Percent Damage Reduction	Average Annual[2] Costs ($1000)	Average Annual Net Benefits ($1000)	BCR[3] @ 6-3/8%
3768.3	2968.9	799.4	78.8	2020.9	948.0	1.47

[1]Includes inundation reduction benefits only.

[2]Does not include O&M or major replacement.

[3]Initial analysis based on an interest rate of 6-3/8 percent.

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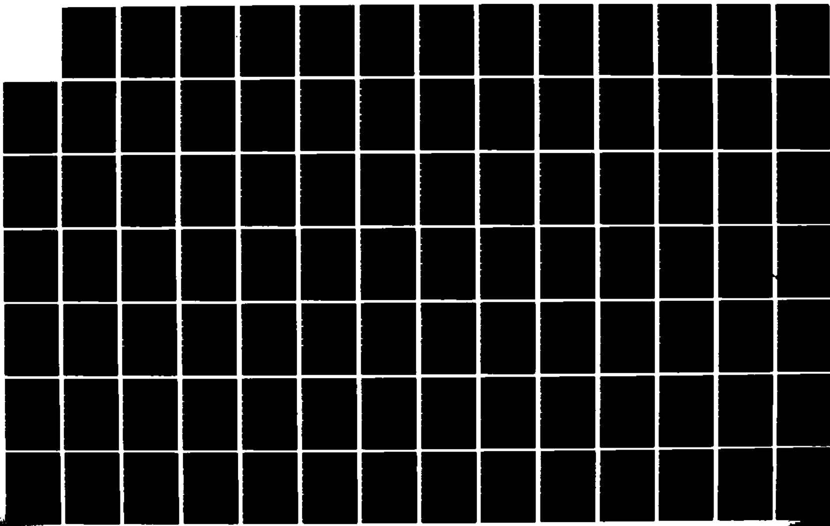

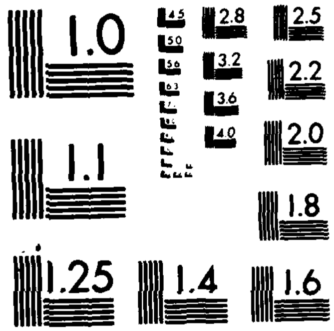

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earlier for flood control. The sequential iteration screening process was again used to progress from very broad planning to individual site planning of greater and greater specificity. Alternative potential recreation scenarios were broadly identified on a single objective basis in order to insure comprehensive inclusion of all practical opportunities. Initial considerations centered upon the identification of the maximum possible opportunities for provision of open space areas for recreational purposes. It was recognized that successful satisfaction of the outdoor recreational need was dependent first upon physical space for its accomplishment and secondly the necessary facilities development. The initial considerations regarding the identification of maximum open space opportunities recognized two broad areas of resource management available in Maline Creek. These were the potential wet and/or dry detention sites and the linear open space possibilities along the water course itself. For convenience of report presentation, the detention site considerations are addressed first, followed by the linear open space analysis.

a. Detention Site Considerations (REC1 Plan). All potential detention sites were originally identified during the flood control analysis. As discussed previously, only those sites that would use existing open space and had suitable topographic features were considered. A total of 17 sites were identified using this criterion and are shown on PLATE B-2 presented earlier. Field inspection of these 17 sites revealed that site MA-1 had significant physical design problems and was dropped from further flood control considerations. However, it was retained during the initial consideration for the recreational analysis. Site MD2-1 had been lost to urban development and, therefore, was no longer considered for any further aspects of this study. For convenience of notation, all of the initial 16 sites were designated as a recreation plan

identified as REC1 Plan. This plan was used as a means for initiating the sequential screening process leading to a comprehensive recreation plan. The REC1 Plan consisted of 16 sites previously listed in TABLE B-4. It was observed during the recreational field reconnaissance that the sites had additional surrounding open space not utilized during the earlier flood control studies. The open space areas suitable for outdoor recreational purposes are shown in TABLE B-12, REC1 Plan.

TABLE B-12
MALINE CREEK
REC1 PLAN

Site	Total Open Space Available (Acres)
M27	82
M22	18
MH1	70
MF1	35
MF2	9
M13	84
MD1	20
MD2-2	58
MD2	37
MD1-1	65
MD1-2	32
MC1	58
MC2	55
MB1	80
MB2	18
MA1	22
TOTAL	743

The REC1 Plan consists of a mix of detention areas plus adjacent open space adapted from the earlier flood control analysis. Other mixes of the total open space acreage utilization could be derived. However, field reconnaissance and judgment regarding seasonal outdoor recreation need satisfaction adopted the REC1 Plan mix shown in TABLE B-12. Further screening and refinement of the initial REC1 Plan focused upon broad preliminary planning estimates of potential

visitor attendance. The planning and analysis of the REC1 Plan at this phase was designed to be broad and preliminary in nature. Initial screenings and considerations were purposely based upon the judgment of personal experience in outdoor recreational planning and management fields. The potential detention site attendance considerations were based on field reconnaissance information which identified specific terrain and topographic features suitable for development and utilization to enhance visitation. The potential visitor attendance was identified for the following categories: lake fisheries, group camping, bicycling, nature walks, game fields, tennis courts, picnicking, and playgrounds. Consideration was also given to adding archery, fitness parcours, and orienteering. However, insufficient participation data precluded their quantification and were thus dropped. The estimated annual visitor day attendance, assuming proper facility development, is shown in TABLE B-13. An additional level of refinement was developed for the REC1 Plan. This consisted of estimating development costs and total costs for each detention site. These cost estimates are only judgmental in nature as is appropriate for the gross level of detail initially pursued. The REC1 Plan costs are presented in terms of the estimated land cost to obtain the detention site plus the cost to obtain the additional available open space lands plus the estimated magnitude of recreational development cost. These values are displayed in TABLE B-14. A gross performance index was prepared excluding a potential land acquisition cost of $450,000. The estimated land costs possibly could be reduced by some dedication of lands by the railroads recognizing their right-of-way is, in any case, abandoned. This right-of-way would serve to connect Bellefontaine County Park, Lange Royce Park, Forestwood Park, detention site M13, and Endicott County Park. The greenbelt along the Maline Creek floodway utilizes some 333 acres spread over its lower 5.5 mile length. Annual visitation would consist of 11,000 bicycling plus 15,000 nature walks, totaling 26,000 visitor days.

TABLE B-13
MALINE CREEK
REC1 PLAN, VISITOR DAY ATTENDANCE

ANNUAL VISITOR DAYS

Detention Site	Fisheries	Group Camping	Bicycling	Nature Walks	Game Fields	Tennis Courts	Picnicking	Playgrounds	Total Visitor Days
M27	1,000 1/	0	2,000	1,500	4,000	1,500	8,900	2,000	20,900
M22	0	0	0	700	3,000	1,500	3,000	1,000	15,500 3/
MH1	0	0	2,000	1,900	5,000	1,500	11,900	2,000	24,300 3/
MF1	0	0	0	1,500	0	0	3,000	0	4,500 4/
MF2	0	0	0	400	2,000	1,500	3,000	2,000	8,900
M13	1,000 1/	0	2,000	1,100	4,000	3,000	11,900	2,000	25,000
MD1	0	0	0	400	2,000	1,500	5,900	1,000	10,800 5/
MD2-2	0	1,600 2/	0	1,500	0	0	11,900	0	15,000 2/
MD2	0	0	0	700	2,000	1,500	5,900	1,000	11,000 6/
MD1-1	1,000 1/	0	2,000	1,500	3,000	3,000	11,900	2,000	14,400 7/
MD1-2	0	0	0	400	2,000	1,500	5,900	1,000	10,800
MC1	0	0	2,000	700	2,000	1,500	5,900	1,000	13,100 6/
MC2	1,000 1/	0	0	700	2,000	1,500	5,900	1,000	12,100 6/
MB1	1,000 1/	0	1,000	1,100	5,000	3,000	11,900	2,000	16,000 6/
MB2	0	0	0	400	2,000	1,500	5,900	0	9,800 8/
MA1	0	0	0	400	2,000	1,500	5,900	1,000	10,800
TOTAL	5,000	1,600	12,000	14,900	40,000	25,500	108,700	19,000	231,700

1/ Fisheries based on provisions of a 5-acre lake.
2/ Group activity at this site because of its location adjacent and within the existing ecological watershed maintained and operated by the Florissant-Ferguson School District.
3/ Pedestrian path and access recommended under new Highway 725 when it is constructed.
4/ Site is surrounded by quasi-public lands currently locally called "The Bird Sanctuary."
5/ Includes a short corridor access to Veterans Memorial Park.
6/ Site is within State of Missouri open space lands currently used as a state correctional boys school.
7/ Site is partially within Hudson Road Park and adjacent to the Florissant Valley Community College.
8/ Site is adjacent to Tanglewood County Park.

TABLE B-14
MALINE CREEK
REC1 PLAN, COSTS

Detention Sites	Detention Area Costs	Recreation Lands Costs	Total Lands Cost	Recreation Development Costs
M27	$ 63,000	$ 19,000	$ 82,000	$ 44,000
M22	16,000	2,000	18,000	216,000
MH1	20,000	50,000	70,000	275,000
MF1	30,000	5,000	35,000	41,000
MF2	6,000	3,000	9,000	106,000
M13	56,000	18,000	84,000	420,000
MD1	10,000	10,000	20,000	111,000
MD2-2	30,000	28,000	58,000	115,000
MD2	15,000	22,000	37,000	178,000
MD1-1	52,000	13,000	65,000	222,000
MD1-2	17,000	15,000	32,000	136,000
MC1	23,000	25,000	58,000	225,000
MC2	49,000	6,000	55,000	171,000
MB1	47,000	33,000	80,000	335,000
MB2	18,000	0	18,000	95,000
MA1	20,000	2,000	22,000	115,000
TOTAL	$472,000	$251,000	$743,000	$2,805,000

Development costs were estimated to be about $87,000, excluding the potential $333,000 land acquisition costs. This flood plain linear as a means of comparing detention sites. This index was computed by dividing the sum of the development cost plus open space lands cost by the total potential visitor day attendance. These calculations are shown in TABLE B-15. This table gives an indication of those sites which display performance characteristics above the average.

b. Linear Park Considerations (REC2 Plan). The second phase of recreational plan formulation dealt with linear park considerations. This plan of potential improvements was called REC2 Plan. It was recognized that the floodway of Maline Creek provides a natural linear greenway. This open space area constitutes much of the remaining undeveloped open space green area in the entire Maline Creek watershed. Map and field inspection disclosed that an additional linear greenway opportunity exists due to the presence of an old abandoned railroad right-of-way. Initial recreational planning focused upon maximum reasonable provision of the open space. The railroad right-of-way considerations included obtaining a 50-foot wide strip along its 7.4 mile length (i.e., 45 acres). The visitor day attendance initially estimated was 15,000 annual bicycling visitations. Estimated development costs were $62,000, park would serve to connect Bellefontaine County Park, Koenenman Park, Lange Royce Park, and Forestwood Park. The combined impact of both the railroad right-of-way plus the creek floodway is to create an oval path of continuous circulation for visitation some 10 miles in length. An additional 3-mile extension would lead from this oval configuration to Endicott Park near St. Charles Rock Road. This linear park configuration is called REC2. The combined linear greening system (REC2 Plan) would accommodate 41,000 annual visitor days.

TABLE B-15
MALINE CREEK
REC1 PLAN, SITE COMPARISONS

Detention Sites	Recreation Land Costs	Recreation Development Costs	Total Recreation Costs	Total Visitor Day Attendance	Costs Divided by Attendance	Above 2/ Average Performance	Priority of Performance
M27	$ 19,000	$ 44,000	$ 63,000	20,900	3.01	Yes	1
M22	2,000	216,000	218,000	15,500	14.06	No	10
MH1	50,000	275,000	325,000	24,300	13.37	No	8
MF1	5,000	41,000	46,000	4,500	10.22	Yes	4
MF2	3,000	106,000	109,000	8,900	12.25	Yes	7
M13	18,000	420,000	438,000	25,000	17.52	No	13
MD1	10,000	111,000	121,000	10,800	11.20	Yes	6
MD2-2	28,000	115,000	143,000	15,000	9.53	Yes	2
MD2	22,000	178,000	200,000	11,100	18.02	No	14
MD1-1	13,000	222,000	235,000	14,400	16.32	No	12
MD1-2	15,000	136,000	151,000	10,800	13.98	No	9
MC1	25,000	225,000	250,000	13,100	19.08	No	15
MC2	6,000	171,000	177,000	12,100	14.63	No	11
MB1	33,000	335,000	368,000	16,000	23.00	No	16
MB2	0	95,000	95,000	9,800	9.69	Yes	3
MA1	2,000	115,000	117,000	10,800	10.83	Yes	5
TOTAL	$251,000	$2,805,000	$3,056,000	231,700	13.19 1/		

1/ Average
2/ Compared to Average (13.19)

c. Combined Linear Park Plus Detention Sites (REC3 Plan). Plan REC3 is a combined system of both the detention sites plus the linear greenway system. The features of the REC3 Plan are shown on PLATE B-3. The total impact of the REC3 Plan on estimated visitor day attendance is shown in TABLE B-16.

TABLE B-16
MALINE CREEK
REC3 PLAN VISITATION

Category	ANNUAL VISITOR DAY ATTENDANCE Detention Sites (REC1 Plan)	Linear Greenway (REC2 Plan)	Total (REC3 Plan)
Fisheries	5,000	0	5,000
Group Camping	1,600	0	1,600
Bicycling	12,000	26,000	38,000
Nature Walks	14,900	15,000	29,900
Game Fields	40,000	0	40,000
Tennis Courts	25,500	0	25,500
Picnicking	108,700	0	108,700
Playgrounds	19,000	0	19,000
TOTAL	231,700	41,000	272,700

31. Alternatives for Addressing Planning Objective 3 (Environmental Enhancement). In APPENDIX A of this report, the principal problems and needs regarding the environmental quality of the Maline Creek watershed were discussed and are related to: stream bank erosion; poor water quality; a lack of aquatic communities; the loss of terrestrial communities; and the accumulation of debris. For each of these environmental concerns, the principal alternative courses of action to address them are identified and presented in the following paragraphs.

a. Stream bank Erosion. Since the stream bank erosion problem has been defined primarily as a problem of urban encroachment on the natural drainage system, two fundamental approaches were specifically analyzed during this stage of

designated in order to clearly demonstrate that all reasonable alternatives were considered. A draft recommended plan was identified by the Corps of Engineers based on the third cycle of formulation as documented in the draft Maline Creek survey report dated March 1978. Careful review of this draft plan by the Corps of Engineers revealed the need to revise the fundamental performance criteria which led directly to the fourth cycle of formulation.

33. The improvements required in fundamental performance criteria related to the flood control objective. Thus, cycle three formulation regarding flood control performance was outdated and is presented in very brief form in this report. That detailed flood information is available for review purposes in the St. Louis District Urban Studies Section. In brief summary, the problems with the third cycle flood control analysis related to a lack of any minimum flood control performance criteria.

34. The data and analysis developed during the third cycle of formulation relative to the outdoor recreation and environmental quality objectives is discussed more fully herein because of its continuing validity.

Outdoor Recreation Focus

35. The formulation of alternative recreation plans in the third cycle of formulation was a refinement addressing outdoor recreation needs, first on a single objective basis. The sequential iteration process was again used to progress from broad planning to more refined individual site planning.

36. The previous recreation scenarios were verified in order to insure comprehensive inclusion of all practical opportunities. The analysis again centered upon the identification of the maximum

possible opportunities for provision of open space areas for recreational purposes. It was verified that the successful satisfaction of outdoor recreational needs was dependent first, upon physical space availability, and second, upon facilities development.

37. The means for capturing maximum open space opportunities again relied upon the two basic management measures identified earlier; wet and/or dry detention sites and the acquisition of linear open space along the stream. For convenience of report presentation, the detention site considerations are addressed first, followed by the linear open space discussion.

a. Detention Site Considerations (REC4 Plan). As discussed earlier, the REC4 Plan consists of 16 detention sites. Refinements in the previous open space considerations are shown in TABLE B-17. The REC4 Plan has a mix of detention sites plus adjacent open space utilization adapted from the earlier flood control analysis. Other mixes of the total open space acreage utilization could be derived. However, field reconnaissance and judgment regarding seasonal outdoor recreation need satisfaction adopted the REC4 Plan mix shown in TABLE B-17. Further screening and refinement of the final REC4 Plan focused upon broad preliminary planning estimates of potential visitor-day attendance. The potential visitor-day attendance was estimated for the following categories: lake fisheries; group camping; bicycling; nature walks; game fields; tennis courts (not counted for benefits purposes); and picnicking.

The estimated annual visitor-day attendance, assuming proper facility deveopment, is shown on TABLE B-18. Further detailing was done for the REC4 Plan, consisting of estimating development costs and total costs for each detention site. The REC4 Plan costs are presented for: the estimated land cost to obtain the detention site; the cost to obtain the additional available open space lands;

and the estimated magnitude of recreational development cost. These values are displayed in TABLE B-19.

b. Linear Park Considerations (REC5 Plan). The second aspect of recreational plan formulation involved linear park considerations. This plan of potential improvements was called REC5 Plan. It was recognized that the floodway of Maline Creek provides a natural linear greenway and that this open space area constitutes a significant portion of the remaining undeveloped open space area in the Maline Creek watershed. In addition to this greenway, map and field inspection disclosed an additional opportunity in the form of an old abandoned railroad right-of-way. The railroad right-of-way considerations included obtaining a 50-foot wide strip along its 7.4 mile length (45 acres). This right-of-way would serve to connect Bellefontaine County Park, Lange Royce Park, Forestwood Park, detention site M13, and Endicott County Park. The green belt along the Maline Creek floodway would utilize some 333 acres spread over its lower 5.5-mile length. This flood plain linear park would serve to connect Bellefontaine County Park, Koenenman Park, Lange Royce Park, and Forestwood Park. The combined effect of both the railroad right-of-way plus the creek floodway would be to create an oval path of continuous circulation for visitati some 10 miles in length. An additional 3-mile extension would lead from this oval configuration to Endicott Park near St. Charles Rock Road. This linear park configuration is called REC5 Plan and is shown on PLATE B-3.

c. Combined Linear Park Plus Detention Sites (REC6 Plan). The REC6 Plan is a combined system of the detention sites and the linear park system. The features of the REC6 Plan are shown in PLATE B-3. The estimated costs and benefits for the REC6 Plan is shown in TABLE B-20.

TABLE B-17
MALINE CREEK
REC4 PLAN
MAXIMUM DETENTION SITES

DETENTION SITE	FLOOD CONTROL AREA (ACRES)	ADDITIONAL OPEN SPACE AREA (ACRES)	TOTAL OPEN SPACE AVAILABLE (ACRES)
M27	20	44	64
M22	5	56	61
MH1	16	58	74
MF1	20	15	35
MF2	6	3	9
M13	16	58	74
MD1	10	10	20
MD2-2	11	50	61
MD2	11	26	37
MD1-1	16	57	73
MD1-2	10	22	32
MC1	16	32	48
MC2	9	46	55
MB1	9	71	80
MB2	9	5	14
MA1	0	22	22
TOTAL	184	575	759

TABLE B-18
MALINE CREEK
REC4 PLAN, VISITOR-DAY ATTENDANCE

DETENTION SITE	FISHERIES	GROUP CAMPING	BICYCLING	NATURE WALKS	GAME FIELDS	TENNIS COURTS	PICNICKING	PLAY-GROUNDS	TOTAL VISITOR-DAYS
	ANNUAL VISITOR-DAYS								
M27	1,000	0	1,750	1,300	3,500	1,500	7,800	1,750	18,600
M22	0	0	0	950	4,000	2,250	4,000	1,350	12,550
MH1	0	0	2,000	1,900	5,000	1,500	11,900	2,000	24,300
MF1	0	0	0	1,500	0	0	3,000	0	4,500
MF2	0	0	0	400	2,000	1,500	3,000	2,000	8,900
M13	1,000	0	2,000	1,100	4,000	3,000	11,900	2,000	25,000
MD1	0	0	0	400	2,000	1,500	5,900	1,000	10,800
MD2-2	0	1,600	0	1,500	0	0	12,025	0	15,125
MD2	0	0	0	700	2,000	1,500	5,900	1,000	11,100
MD1-1	1,000	0	1,100	1,700	3,350	3,000	12,025	2,220	24,620
MD1-2	0	0	0	400	1,500	1,500	5,900	1,000	10,300
MC1	0	0	0	700	700	1,500	5,900	1,000	11,800
MC2	1,000	0	0	700	700	1,500	5,900	1,000	10,800
MB1	1,000	0	1,000	1,100	1,100	3,000	11,900	2,000	21,100
MB2	0	0	0	375	1,850	1,500	5,450	0	9,175
MA1	0	0	0	400	2,000	1,500	5,900	1,000	10,800
TOTAL	5,000	1,600	9,850	15,125	33,700	26,250	118,625	19,320	229,470

TABLE B-19
MALINE CREEK
REC4 PLAN, COSTS

DETENTION SITES	DETENTION AREA COSTS	RECREATION LAND COSTS	TOTAL LAND COSTS	RECREATION DEVELOPMENT COSTS
M27	$ 200,000	$ 440,000	$ 640,000	$ 38,350
M22	50,000	560,000	610,000	287,300
MH1	160,000	580,000	740,000	275,000
MF1	200,000	150,000	350,000	41,000
MF2	60,000	30,000	90,000	106,000
M13	160,000	580,000	740,000	420,000
MD1	100,000	100,000	200,000	111,000
MD2-2	110,000	500,000	610,000	116,000
MD2	110,000	260,000	370,000	178,000
MD1-1	160,000	570,000	730,000	247,000
MD1-2	100,000	220,000	320,000	136,000
MC1	160,000	320,000	480,000	225,000
MC2	90,000	460,000	550,000	171,000
MB1	90,000	710,000	800,000	335,000
MB2	90,000	50,000	140,000	88,000
MA1	0	220,000	220,000	115,000
TOTAL	$3,350,000	$4,240,000	$7,590,000	$2,889,000

38. The maximum recreation plan (REC6 Plan) was identified as the prime social well-being candidate. It should be noted, however, that many recreation interests overlap with EQ interests. For example, trails can be used for bicycling and nature walks, while the quality of the recreation experience can be enhanced by the presence of trees, shrubs, and water bodies. As a result, the social well-being plan, by its very nature, addresses not only the recreation needs, but also aspects of environmental enhancement that together improve the quality of life and social well-being for all inhabitants of the watershed.

Environmental Quality Focus

39. Environmental quality (EQ) considerations, were categorized as generators of primarily intangible benefits. Work on the EQ plans was based on an extension and refinement of the previous EQ considerations.

40. From the outset, the most significant aspect of the comprehensive Maline Creek environment, including all flora and fauna inhabiting the area, was mankind. However, the EQ plan was prepared to focus on the needs of fish and wildlife, specifically exclusive of mankind and his domestic animals. This approach was adopted in order that the paramount importance of mankind would not obscure any fish and wildlife opportunities that may be present. The intense urbanization of the Maline Creek watershed is reflected in the flood control portion of the study. The flood control work effort considered some tangible aspects of environmental quality as related to mankind during that analysis. Establishing commonalities between basic objectives was considered to be a positive step toward creation of a final recommended plan.

TABLE B-20

MALINE CREEK

REC6 PLAN COSTS AND BENEFITS

($1,000)

ITEM	DETENTION	LINEAR TRAIL	TOTAL
I. SUMMARY OF FIRST COSTS			
A. Detention			
1. Land Costs	$ 7,590	$ 0	$ 7,590
2. Development Costs	2,889	0	2,889
3. (Sub-total)	($10,479)	($ 0)	($10,479)
B. Linear Trail			
1. Flood plain Area			
a. Land Costs	0	$3,330	$ 3,330
b. Development Costs	0	87	87
c. (Sub-total)	($ 0)	($3,417)	($ 3,417)
2. Railroad Right-of-Way			
a. Land Costs	$ 0	$4,500	$ 4,500
b. Development Costs	0	62	62
c. (Sub-total)	($ 0)	($4,562)	($ 4,562)
C. Total First Costs	$10,479	$7,979	$18,458
II. AVERAGE ANNUAL COSTS			
A. Interest and Amortization of First Costs @ 6-5/8% for 100 Years	$ 695	$ 530	$ 1,225
B. Annual Operation, Maintenance, and Major Replacement Costs	53	39	92
C. Total Average Annual Costs	$ 748	$ 569	$ 1,317
III. AVERAGE ANNUAL BENEFITS			
A. Detention Sites	$ 229	$ 0	$ 229
B. Flood plain Trail	0	26	26
C. Railroad Right-c - Trail	0	15	15
D. Total Average An... Benefits	$ 229	$ 41	$ 270

41. The principal aesthetic and environmental problems and opportunities in the Maline Creek watershed were discussed in APPENDIX A of this report and discussed earlier in this appendix. These problems and needs fall into the following general categories: stream bank erosion, water quality, aquatic habitat diversity, terrestrial communities, and litter and debris. As the next step in the planning process, a plan was developed to address each of these areas of concern. The principal measures to address these concerns, taken from the array of measures carried forward during the initial screening described earlier in this appendix, are identified and presented in the following paragraphs.

a. Streambank Erosion. Streambank erosion is generally regarded as a local problem, only affecting a few property owners in the immediate vicinity of the eroding stream bank. However, for purposes of this study, stream bank erosion was identified as a need that must be satisfied for safety and aesthetic reasons and to help insure the success of other improvement measures. Streambank stabilization, called Plan EQ1, was considered the most practical measure for solving the stream bank erosion problem. This solution involves the use of aesthetically pleasing materials, such as gabions, to protect the banks in the most serious erosion areas. The areas in which stream bank stabilization structures would be placed are shown on PLATE B-4. These problems are located in damage reaches M2, M4, M5, M7, M9, M10, M12, M16, MB, MD1, MD2, MD3, and MH, in addition to five areas upstream from the modeled flood control reaches. For purposes of this report, gabion-lined channel was selected as the most practical and aesthetically pleasing structure. Since the primary objective is to address stream bank erosion, an extra small size was used for each reach. Gabion structures would be placed along the eroding bank and as far upstream or downstream as necessary for stability. The stream bank erosion reduction benefits were unquantifiable.

b. Water Quality. As mentioned in APPENDIX A, this problem is being addressed by the East-West Gateway Coordinating Council. Poor water quality is recognized as a severely limiting factor in the production of aquatic organisms in the watershed. This problem must be improved before any significant benefits can be realized from measures to increase the aquatic habitat diversity in the watershed.

c. Aquatic Habitat Diversity. A lack of aquatic habitat diversity has been identified as an important factor limiting the production of fish and other aquatic organisms in the Maline Creek watershed. This problem has been addressed by the development of a plan, called Plan EQ2, consisting of two measures: fish ponds and aquatic habitat structures. A primary means of increasing the aquatic habitat diversity within the watershed is the construction of fish ponds. Therefore, the detention basins under consideration for flood control purposes were also considered initially as pond sites to provide increased habitat for fish and other desirable aquatic organisms. The factors considered in selecting suitable fish pond sites are as follows:

(1) Ponds should be distributed throughout the watershed.

(2) More than 50 percent of the drainage area should be undeveloped. The long-term usefulness of these ponds would require that the undeveloped drainage area be protected from intensive development, as provided for in the sub-paragraph below entitled "Terrestrial Communities."

(3) The detention area should not be unique wildlife habitat.

(4) Ponds should not be less than 1 acre in size, with a drainage area to water surface ratio of at least 6 to 1 but not

greater than 20 to 1. Twelve sites ranging in size from 1 to 6 acres were found suitable for fish ponds. The sites are shown on PLATE B-5, and pond sizes are given in TABLE B-21. Pond locations were selected where a dam could be constructed with a 10-foot high spillway, and provide the required water surface acreage and water surface to drainage area ratio. It was assumed that a borrow pit could be excavated in the bottom of the pond to provide a desirable 15-foot maximum depth for the water. Tangible benefits for the fish ponds were derived by the same methods used for figuring recreation benefits. It was assumed that annual fisherman use of the 37 acres of fish ponds possible by this measure would be 730 user-days per acre. This total use (27,010) was multiplied by a $1.75 value per fisherman-day to arrive at a total annual user benefit value of $47,300 for this plan. Costs of the fish ponds include real estate, pond construction, and construction of a small parking lot and a flush toilet at each site. Total annual costs for this measure would be $332,400 at a 6-5/8 percent interest rate (all costs are in October 1977 dollars). A second means of increasing the aquatic habitat diversity within the watershed is the construction of aquatic habitat structures. These structures would be located at approximately 0.25-mile intervals in stream sections having an average annual flow of 5 cubic feet per second. The approximate upstream limits would be North Hanley Road on the main channel and Chambers Road on Tributary MD (see PLATE B-6). Structures would be located at sites where the excavated bottom would not endanger adjacent bank stability. Pools would be 30 feet in length, sloping from 3 to 5 feet in depth. Width would vary depending upon the existing channel width. Pool walls and bottom would be constructed of aesthetically pleasing materials, such as gabions. The side walls would be staggered to provide fish cover. Tangible benefits for the aquatic habitat measure were estimated by the following method prescribed for figuring recreation benefits. It was assumed that annual fisherman use of the 9 miles of stream affected by this

TABLE B-21
MALINE CREEK
FISH PONDS

SITE	WATER SURFACE ACRES
MB1	6
MB2	3
MC1	2
MC2	4
MD2	1
MD1-1	2
MD1-2	2
MD2-2	4
MH1	2
M13	5
M22	2
M27	4
TOTAL	37

measure would be 220 fisherman-days per mile. This total (1,980 fisherman-days) was multiplied by $1.75 per fisherman-day to yield a total annual user benefit of $3,500 for this measure. Costs of this measure include real estate and construction. Total annual costs would be $207,500 at a 6-5/8 percent interest rate. The results of these analyses show that Plan EQ2 returns quantifiable average annual benefits of $50,800, total annual costs of $539,900 at a 6-5/8 percent interest rate.

d. Terrestrial Communities. The anticipated continued conversion to other land uses of undeveloped areas that are the primary habitat for terrestrial wildlife has been identified as a major environmental problem in the Maline Creek watershed. This problem has been addressed by the development of a plan, called Plan EQ3, consisting of two measures: land acquisition and wildlife management practices. The most effective measure to address this problem is to acquire those remaining lands presently supporting terrestrial communities, including larger individual tracts of land as well as the undeveloped flood plain. Eighteen undeveloped areas (PLATE B-7), totaling 1,369 acres, have been identified for possible preservation and management as wildlife habitat. All of these areas were subjectively ranked on a 1 to 5 scale as to their value to wildlife for each of the following parameters: size; plant diversity; accessibility; preferred food species; aesthetics; and disturbance. TABLE B-22 shows the ratings for each site. The size, wildlife value, ownership, and whether a reservoir is planned are shown for each site on TABLE B-23. In addition to the individual sites, the undeveloped flood plain of Maline Creek would be protected to provide a continuous undeveloped corridor between many of the larger undeveloped areas. A total of 393 acres along 21 miles of creek were identified as desirable terrestrial habitat areas (See PLATE B-8). In addition to its value as wildlife habitat, the preservation of this corridor would aid in noise

abatement and erosion control. Each 100-foot width of trees can absorb about 6-8 decibels of sound intensity. Since noise has been identified as a problem in the Maline Creek watershed, as many trees should be preserved as practicable. In addition, trees as windbreaks have the potential to reduce winter fuel consumption by 10 to 25 percent (Heisler, 1977). Trees can also cause reduced summer cooling costs; however, shade can also increase winter fuel costs. TABLE B-23 lists the land areas required for this plan in order of priority. To determine the priority, four parameters were considered. The first was whether the area (or part of it) was in public or private ownership. This was considered to be the most important criteria because threat of loss through urban development is greatest for privately owned tracts. The next most important parameter was whether a fish pond site was suitable for the area. This was considered more important than wildlife habitat quality, the third most important parameter, because habitat quality can be improved by wildlife management measures. The fourth and last parameter was the size of either the private portion of each tract or the total size if the size of the private portion was unknown or if the parcel was all in public ownership. The wildlife management measure would involve activities on both project and off-project lands. First, each of the larger tracts that are eventually preserved by the selected plan would be evaluated by wildlife biologists from the St. Louis District in cooperation with the Missouri Department of Conservation and the St. Louis County Parks Department, and a management plan developed. Some of the undisturbed areas should require a minimum of management; however, in some areas such as the large open grass area in Bellefontaine Park, an opportunity for habitat enhancement exists by planting some food and cover species. The addition of the small fish ponds (provided for in the preceding paragraph) would enhance the wildlife habitat by adding to the diversity and providing a source of permanent water. Second, a substantial opportunity for wildlife

TABLE B-22
MALINE CREEK
WILDLIFE HABITAT RATINGS

AREA	A	B	C	D	E	F	TOTAL	CLASS**
	PARAMETERS + RATINGS*							
M13	2	3	2	2	3	2	14	3
M22	4	3	3	2	2	1	15	3
MH1	5	5	2	4	2	3	21	1
MB2	2	2	3	2	2	1	12	3
MB1	4	2	3	2	2	1	14	3
MC2	3	2	4	2	2	2	15	2
MC1	3	1	4	1	2	1	12	3
MD2	2	1	2	2	2	1	10	3
MD1-1	5	3	3	4	5	5	25	1
MD1-2	2	3	3	2	3	3	16	2
MD2-2	5	4	5	5	5	4	28	1
M27	4	4	5	2	2	2	19	2
1	2	2	4	2	2	1	13	3
2	2	2	2	4	4	3	17	2
3	2	3	2	2	3	2	14	3
4	4	2	4	2	3	2	17	2
5	4	4	4	3	3	2	20	1
6	3	4	4	3	5	4	23	1

* Parameters: (A) Size, (B) Diversity, (C) Accessibility, (D) Preferred Vegetation, (E) Aesthetics, (F) Disturbance.

Rating is based on a scale of 1 (Worst) to 5 (Best).

** Class: 1 - Excellent; 2 - Good; 3 - Marginal.
(21 = 30) (15 = 20) (0 = 14)

TABLE B-23
MALINE CREEK
LAND REQUIREMENTS AND EQ FEATURES

AREA* DESIGNATION	RESERVOIR PRESENT	WILDLIFE HABITAT** QUALITY	AREA (ACRES) PUBLIC	PRIVATE	TOTAL
MD2-2	X	1	86	58	144
MH1	X	1	Unknown	Unknown	140
MD1-1	X	1	Unknown	Unknown	87
M27	X	2	20	150	170
M22	X	2	0	72	72
MD1-2	X	2	0	32	32
M13	X	3	0	84	84
MB2	X	3	Unknown	Unknown	18
MF1	X	1	0	35	35
5	-	1	10	7	17
2	-	2	0	22	22
4	-	2	185	16	201
1	-	3	Unknown	Unknown	33
MC2	X	2	55	0	55
MD2	X	2	37	0	37
MB1	X	3	80	0	80
MC1	X	3	58	0	58
3	-	3	84	0	84
Subtotal					1,369
Wildlife Corridor			Unknown	Unknown	393
Total					1,762

* Areas are listed in order of their acquisition priority.
** Excellent - 1; Good - 2; Marginal - 3.

habitat development exists on the residential land in the watershed. A study by Dagg (1974) on reactions of people to urban wildlife indicates most people like birds, except for starlings and pigeons. Backyard wildlife habitat enhancement would generally increase the number of preferred bird species. Small mammals were not as popular as birds, with only about half of the species surveyed having a greater than 50 percent popularity; however, birds are the most visable wildlife in the urban setting. There are approximately 39,000 households in the Maline Creek watershed; and according to a study by De Graaf and Payne (1975), about 7,800 (20 percent) participate in feeding wild birds. Using figures developed in the referenced study, approximately $266,000 per year is spent on nature-related activities in the watershed. This indicates a substantial interest; however, in many cases people may not be aware of measures they could take to improve their backyard as wildlife habitat. The Missouri Department of Conservation has added an urban wildlife biologist to their staff to help implement urban wildlife programs. The following measures could be taken to encourage the development of residential wildlife habitat:

(1) Provide technical assistance and plantings to interested individuals and organizations. The Missouri Department of Conservation is developing a wildlife "bundle" of trees and shrubs for this urban area.

(2) Establish wildlife demonstration areas on public land such as county park land. These areas could simulate typical backyards and show management practices which could be used. Printed material could be available such as Invite Wildlife to Your Backyard from the National Wildlife Federation. Three "10-year old" backyards could be established on public land at a cost of $5,000 each, as well as three "1-year old" backyards at a cost of $300 each. Every 10 years of project life, three new "1-year old"

backyards could be planted. Each demonstration backyard could be maintained in a normal way, such as trimming shrubs and mowing lawns.

(3) Conduct wildlife management seminars by wildlife professionals for interested individuals. These seminars could be used to discuss backyard wildlife management techniques and make literature available.

(4) Utilize interested individuals to volunteer their backyards as showplaces for wildlife management practices. Members of the local conservation groups such as the Audubon Society could be encouraged to participate.

(5) Have a specific program to encourage people to participate in a backyard wildlife habitat enhancement program. A study by the U. S. Forest Service Northeastern Forest Experiment Station found that trees increased residential property value by an average of 5 to 10 percent. The cost of establishing a backyard wildlife program is estimated at $250 per backyard using a combination of seedlings from the Missouri Department of Conservation plus a few larger trees from commercial nurseries. The median value for residential property in the study area of $16,900 was used to compute benefits. Payne and Strom (1975) found that for undeveloped land, the optimal amount of forest cover for maximum property value was two-thirds forest cover with a scattered arrangement. These figures are used in TABLE B-24 to demonstrate the anticipated effect of a backyard wildlife program on property values in Maline Creek. Other benefits that backyard wildlife plantings could have are noise reduction, fuel savings, and air pollution abatement. One of the most difficult values to measure is the enjoyment that many people obtain from viewing wildlife. Cauley (1974) reports that 76 percent of the people interviewed stated they liked and enjoyed seeing wildlife on their property. One's own backyard probably offers the best opportunity for this practice.

42. Tangible benefits for the land acquisition measure of Plan EQ3 were derived from user benefits in the following manner. A total of 45 miles of nature trails would be developed in the preserved areas. This includes 23 miles of trail along either side of the creek, plus 22 miles in the larger tracts. However, only 31 miles of nature hiking trails are needed in the Maline Creek watershed. The figure of 31 miles was multipled by the number of anticipated nature hikers per mile (3,560) to arrive at a total annual number of 81,880 nature hikers. A value of $1.75 per hiker-day multiplied by 81,880 yields $193,000 annual user benefits for this plan. No tangible benefits were calculated for the wildlife management measure. Costs of Plan EQ3 include real estate, construction of 15 small parking lots plus plantings for the wildlife demonstration areas. Total annual costs at a 6-5/8 percent interest rate are $1,676,000.

e. Litter and Debris. Litter and debris removal is generally a local problem. However, in order to provide an aesthetically pleasing area in which to enjoy nature hiking, it was considered necessary to clean up the stream banks along the corridor provided in Plan EQ3. To solve this problem, a one-measure plan, called Plan EQ4, was developed. This would involve the cleanup and maintenance of litter and debris on all project lands along the corridor. The initial cleanup would be part of any recommended plan of improvements. Thereafter, maintenance of these areas would be a local requirement. Annual benefits of Plan EQ4 are unquantifiable. Total annual costs are $32,500 at a 6-5/8 percent interest rate.

f. Noise. Although noise has been identified as a problem in the project area, no specific measures have been formulated to address this problem since it is not water-resource related. However, the preservation of terrestrial communities, including the Maline Creek flood plain and the larger habitat areas, as well as

TABLE B-24
MALINE CREEK
BACKYARD WILDLIFE PROGRAM FOR RESIDENTIAL AREAS

COVER CLASS	(% COVER)	ACRES	(%)	NO. OF HOUSES	VALUE ADDED* %	VALUE ADDED* VALUE**	COSTS***	BCR
M1	75	199	1.6	125	0	$ 0	$ 31,250	
M2	65	998	8.0	624	0	0	156,000	
M3	55	6,654	53.2	4,150	1.1	771,485	1,037,500	
M4	45	4,460	35.6	2,777	2.2	1,032,489	694,250	
M5	35	206	1.6	125	3.4	71,825	31,250	
TOTALS		12,517 ac	(100.0%)	7,801		$1,875,799	$1,950,250	.96

*The maximum value added would be 7.5% from an area with no trees to one with 65% tree cover.

**A median $16,900 property value was used.

***An average cost of $250 per yard was used.

implementation of the backyard wildlife plantings, would help alleviate ground-level noise intrusions.

43. Maximum EQ Plan. For the purpose of benefit and cost analysis, the entire spectrum of measures from Plans EQ1 through EQ4 were considered as a maximum EQ Plan, designated Plan EQ5 (See PLATE B-9). This was considered appropriate because the plans would complement each other in purpose and would exhibit synergistic impacts. Quantifiable benefits from Plan EQ5 were derived strictly from user benefits. The benefits include fishermen use of fish ponds and nine miles of stream in which the aquatic habitat structures are constructed; nature walking on trails developed on the land acquired for stream bank stabilization; and wildlife habitat preservation purposes. Costs of plan EQ5 include real estate, construction of stream bank stabilization structures, fish ponds, aquatic habitat structures, and development of project lands (including appropriate plantings with parking lots and toilets to service the larger trails). The results of the cost analysis show that Plan EQ5 returns $243,800 in tangible average annual benefits at a cost of $2,403,300 total average annual costs. It is considered that the many intangible benefits that would be derived from Plan EQ5 outweigh the costs. Therefore, the EQ features described above were carried forward for further consideration as potential components of the recommended plan of improvements.

Draft Conventional Plan (Multi-Objective Focus)

44. The final screening of the 136 alternatives prepared during the third cycle of formulation was directed to identification of a draft multiple-objective conventional plan. A number of various economic efficiency type tests were used which require little explanation or interpretation. However, one performance test was developed to help evaluate environmental impacts that merits further

explanation. An environmental sensitivity testing procedure was developed as an aid to insuring the fullest possible real consideration be made and considered during alternative plan comparisons.

45. Environmental sensitivity test. Environmental quality criteria were used to test the plans developed in the third cycle of formulation. Analyses of the existing and probable future environmental conditions of the highly urbanized Maline Creek watershed quickly led to the realization that a great deal of the natural terrestrial and aquatic flora and fauna had already been irreparably lost. At the same time it was recognized that preservation and/or restoration of normally insignificant levels of terrestrial and aquatic habitats (both quantity as well as quality) would be highly desirable due to Maline Creek's highly developed urban setting. Provision for some measure of non-urbanization would help fulfill a major urban need category. Preservation of the severely limited existing open space in areas adjacent to Maline Creek would have a dual benefit in that continued development of the most highly flood susceptable areas would be avoided in favor of the needed open space. With these broad environmental considerations in mind, a team of Corps of Engineers natural scientists identified and weighed eight environmentally oriented criteria suitable to tangible flood control plan screening. The environmental sensitivity of a flood control plan of improvements was based on the weighted sum of the eight environmental criteria.

46. More specifically, each of the plans was rated on a stream reach and detention site specific performance index which was then weighed relative to the other seven environmental criteria. A total weighted environmental score was thus obtained as a measure of relative environmental sensitivity. The numerically oriented technique was adopted in order to establish a direct and systematic

methodology for evaluating, comparing, and screening the remaining alternative plans of improvements. The eight environmental criteria and their relative weights are discussed in the following subparagraphs.

a. The first environmental quality criterion was assigned a value of ten (the eight criterions' sum equals 100). This value was based on a team of natural scientists' judgment regarding the relative importance of each environmental criterion. This first criterion focuses upon the amount of natural terrestrial habitat preserved by each alternative plan of improvement. Channel improvements and detention sites are able to preserve the existing terrestrial habitat as a secondary impact to their primary flood control function. Thus, the greater the acreage of natural terrestrial habitat preserved, the greater is the plan's relative ranking. No credit was given to a plan which required the existing open space to be cleared of flora first, seeded or sodded, and then preserved. The specific application of this test consisted of assigning values based upon the maximum transfer of land (public and private) to project ownership via channel improvements or the EQ/recreation stream corridor acquisitions. Detention site improvements were evaluated by the second environmental quality criterion.

b. The second environmental quality criterion was assigned a value of 20. This criterion focuses on transfering the greatest amount of wildlife habitat to project ownership. Again, no credit was given if the lands must be cleared prior to preservation. Specific application of this test consisted of assigning environmental credit if the installation of detention site improvements or large tract acquisition was proposed. The stream channel improvements were not credited in this analysis because of their limited application.

c. The third environmental quality criterion was assigned a value of 15. This criterion focuses on the preservation of the greatest amount of "good" to "excellent" quality detention site habitat. Tracts that fall into these high-quality categories are located at the potential detention site areas MH1, M22, MD2-2, MC2, MD2, MD1-2, and wildlife habitat tracts 2, 4, and 5. This test consisted of assigning the highest values to those plans that transferred the high-quality sites to project ownership.

d. The fourth environmental quality criterion was assigned a value of 10. This criterion focuses upon the preservation of the greatest amount of "good" to "excellent" quality flood plain habitat. Tracts that fall into these high-quality categories are M1, M2, M3, and M4. This test consisted of assigning the highest values to those plans that transferred these quality sites to project ownership.

e. The fifth environmental quality criterion was assigned a value of 10. This criterion focuses on the minimization of channel site clearing. Those plans of improvements that cause the least amount of clearing were rated highest.

f. The sixth environmental quality criterion was assigned a value of 15. This criterion gives credit to maintaining the stream channel in an unimproved state. Those plans that have the fewest channel improvements are ranked highest.

g. The seventh environmental quality criterion was assigned a value of 10. This criterion gives credit to the preservation of natural aquatic habitat. Thus, plans were ranked based on the aquatic habitat compatibility of the channel measures installed. No action was assigned the highest value, gabions second, earth channel third, and concrete channels last.

h. The eighth environmental quality criterion was assigned a value of 10. This criterion gives credit to the installation of environmentally compatible stream bank stabilization improvements in each stream reach where erosion has been identified as a significant problem. These reaches are M2, M4, M5, M7, M9, M10, M12, M16, MB, MD1, MD2, MD3, MD4, MF1 and MH. Credit is also given in a proportional manner for stabilization of bank erosion problems upstream of the designated stream reaches.

i. The final step in the environmental sensitivity analysis was accomplished to equitably balance the eight criteria accounting systems. This step consisted of normalizing the technical identification count of all light criteria by converting all scores to their weighted relative base.

47. Draft Conventional Plan (Multi-Objective Focus). Based on the third cycle formulation screenings, Plan 123 was selected as the draft conventional plan from the final array of six alternatives. This conclusion is based on Plan 123's superior impacts in each performance category. The six best performing multi-objective plans are shown in TABLE B-25 for comparison purposes. Because of plan 124's superior performance with respect to national economic development (NED) considerations, it was designated the draft NED plan. Because of plan 128's superior environmental quality (EQ) performance, it was designated the draft EQ plan.

48. The system impacts of the no action alternative, the NED Plan (124), the EQ Plan (128), and the cycle three draft conventional plan (123) are displayed in summary form the system of accounts included as TABLE B-26. The complete system of account analysis is on file and available for review purposes with the Urban Studies Section, St. Louis District, Corps of Engineers. The cycle three draft conventional plan was carried through the fourth and final

TABLE B-25
MALINE CREEK
PERFORMANCE OF PLANS 123 THROUGH 128

	ITEM	PLANS 123	124	125	126	127	128
1.	Base flood control plan	117	73	57	82	53	80
2.	Ave. Ann. Benefits ($1000)	3,563	2,830	3,979	3,102	1,983	4,219
	(Flood Control)	(2,628)	(2,223)	(2,925)	(2,363)	(869)	(2,833)
	(All other)	(935)	(607)	(1,054)	(739)	(1,114)	(1,386)
3.	Ave. Ann. Costs ($1000)	2,123	1,101	3,241	2,876	1,817	3,950
	(Flood Control)	(1,526)	(803)	(2,863)	(2,136)	(890)	(2,651)
	(All other)	(597)	(298)	(378)	(740)	(927)	(1,299)
4.	Benefit to Cost Ratio	1.68	2.57	1.23	1.08	1.09	1.07
	(Flood Control)	(1.72)	(2.77)	(1.02)	(1.11)	(0.98)	(1.07)
	(All other)	(1.57)	(2.04)	(2.79)	(1.00)	(1.23)	(1.07)
5.	Ave. Ann. Net Benefits ($1000)	1,440	1,729	738	226	166	269
	(Flood Control)	(1,102)	(1,420)	(62)	(227)	(-21)	(182)
	(All other)	(338)	(309)	(676)	(-1)	(187)	(87)
6.	Percent flood damage reduction	70	59	78	63	23	75
7.	Net ave. ann. induced flood damages ($1000)	3	67	22	15	0	0
8.	Home relocations required	3	22	129	7	0	33
9.	Environmental sensitivity test	54	37	43	49	65	75

TABLE B-26
MALINE CREEK
SUMMARY OF MAJOR BENEFICIAL AND ADVERSE EFFECTS

	NO PROJECT ALTERNATIVE (WITHOUT CONDITION)	NED PLAN	EQ PLAN	CYCLE THREE "CONVENTIONAL" PLAN 123 (UNREFINED)
1. PLAN DATA				
Flood Control Components	No major structural improvements	Channel modification: 3.1 miles of widening and straightening; Detention Basins: none	Channel modification: 5.7 miles of widening and straightening; Detention Basins: 15 sites	Channel modification: 4.6 miles of widening and straightening; Detention Basins: 8 sites
Other Components	Flood plain regulations; participation in, and compliance with National Flood Insurance Program	Flood plain regulations; participation in, and compliance with National Flood Insurance Program plus 2 aquatic habitat structures, 267 acres open space acquisition, 1200 feet streambank stabilization	Flood plain regulations; participation in, and compliance with National Flood Insurance Program plus 12 aquatic habitat structures, 12 fish ponds, 842 acres open space acquisition, 7900 feet stream bank stabilization	Flood plain regulations; participation in, and compliance with Nationsal Flood Insurance Program plus 3 aquatic habitat structures, 403 acres open space acquisition, 5 fish ponds, 4000 feet stream bank stabilization
2. NATIONAL ECONOMIC DEVELOPMENT				
Beneficial Effects	Reduction in future flood damages - not quantified	$2,223,000 average annual flood damage reduction; $607,000 average annual recreation benefits; $52,000 average annual redevelopment benefits	$2,833,000 average annual flood damage reduction; $1,386,000 average annual recreation benefits; $480,000 average annual redevelopment benefits	$2,628,000 average annual flood damage reduction; $935,000 average annual recreation benefits; $109,000 average annual redevelopment benefits

TABLE B-26 (Continued)
MALINE CREEK
SUMMARY OF MAJOR BENEFICIAL AND ADVERSE EFFECTS

	NO PROJECT ALTERNATIVE (WITHOUT CONDITION)	NED PLAN	EQ PLAN	CYCLE THREE "CONVENTIONAL" PLAN 123 (UNREFINED)
Adverse Effects	Continuation of damages, relocation costs, flood insurance administration costs - $3.7 million average annual damages	$730,000 average annual flood control costs; $320,000 average annual EQ/REC costs; $51,000 average annual O&M costs; $68,000 average annual Loss of Productivity	$2,370,000 average annual flood control costs; $1,299,000 average annual EQ/REC costs; $215,000 average annual O&M costs; $251,000 average annual Loss of Productivity	$1,346,000 average annual flood control costs; $642,000 average annual EQ/REC costs; $188,000 average annual O&M costs; $129,000 average annual Loss of Productivity
Net Effects	Negative, Not Quantified	$2,882,000 benefits/ $1,169,000 costs/2.47 BCR	$4,399,000 benefits/ $4,135,000 costs/1.06 BCR	$3,672,000 benefits/ $2.305,000 costs/1.59 BCR
3. ENVIRONMENTAL QUALITY				
Beneficial Effects	Insignificant	Erosion control, mitigation acreage, and corridor preservation acreage; and recreational development	Erosion control, habitat diversity, and improvement, mitigation acreage, park acreage, and corridor acreage; wildlife management of public lands and recreational development	Erosion control, habitat diversity, and improvement, mitigation acreage, park acreage, and corridor acreage; recreational development
Adverse Effects	Degradation and destruction due to urbanization, flooding, and erosion, Not Quantified	Pollution, disruption, siltation, channel shortening, and habitat destruction due to project construction; urbanization	Pollution, disruption, siltation, channel shortening, and habitat destruction due to project construction; urbanization	Pollution, disruption, siltation, channel shortening, and habitat destruction due to project construction; urbanization
Net Effects	Adverse, Not Quantified	Not Quantifiable	Positive, Not Quantifiable	

TABLE B-26 (Continued)
MALINE CREEK
SUMMARY OF MAJOR BENEFICIAL AND ADVERSE EFFECTS

	NO PROJECT ALTERNATIVE (WITHOUT CONDITION)	NED PLAN	EQ PLAN	CYCLE THREE "CONVENTIONAL" PLAN 123 (UNREFINED)
4. SOCIAL WELL-BEING				
Beneficial Effects	Gradually reduces susceptability to flooding	Flood protection, recreational and aesthetic improvements, and increased incomes due to employment	Flood protection, recreational and aesthetic improvements, and increased incomes due to employment	Flood protection, recreational and aesthetic improvements, and increased incomes due to employment
Adverse Effects	Community and individual disruption due to relocation and flooding; additional	Temporary inconveniences during construction and relocations	Temporary inconveniences during construction and relocations plus recreational and habitat areas considered hazard/nuisance by some	Temporary inconveniences during construction and relocations plus recreational and habitat areas considered hazard/nuisance by some
Net Effects	Adverse	Positive, Not Quantified	Positive, Not Quantified	
5. REGIONAL DEVELOPMENT				
Beneficial Effects	Insignificant	Insignificant	Insignificant	Insignificant
Adverse Effects	Insignificant	Insignificant	Insignificant	Insignificant
Net Effects	Insignificant	Insignificant	Insignificant	Insignificant

formulation cycle in spite of all the additional final screening criteria. This was done in order to insure the widest possible realistic diversity in final decision alternatives. The cycle three draft conventional plan utilizes "conventional" flood control management measures (i.e., detention reservoirs and channel improvements) to mitigate flood damages.

49. The planning process during the fourth iteration used an update of the previous revised formulation rationale and screening process. Corps of Engineers' review of the results of the third iterative cycle of plan formulation indicated that improvements in flood control performance were necessary.

Additional Formulation Criteria

50. The following additional formulation criteria were adopted so as to refine and improve on the third cycle plan formulation screening of alternatives. Three plans were carried through to final decision making that did not satisfy all additional formulation criteria shown below. They are a "traditional" plan, a nonstructural plan and the cycle three "conventional" plan. These additional alternatives were included in order to be certain that simply establishing various technical formulation criteria did not screen out some potentially viable alternative. Including a "pure" nonstructural alternative plan (actually two such plans) was purposefully done, despite their very poor economic and social well-being performance, as a means to insuring maximum flexibility in local decision making and to demonstrate the fullest possible comprehensive search for practical solutions.

a. Average annual net induced damages will not exceed $10,000.

b. A uniform minimum level 10-year frequency will be provided for each improved stream reach. This represents a subobjective developed to insure a minimum plan performance as a community service and was found to have no significant impact on the concept of maximization of net benefits.

c. No improvements will be proposed that create significantly hazardous or catastrophic situations in the event of failure of those improvements. In other words, great care will be exercised to avoid proposing any improvement that may result in a "safety trap."

d. In order to provide a conservative margin of economic justification, all plans of improvements will be screened on a performance criterion of a 1.2 BCR. This constraint was found to have no significant impact on the concept of maximization of net benefits. The austere criteria are intended to help assure that any final proposal is economically sound even with uncertain future socio-economic projections.

Update of Management Measures

51. The effectiveness of the previously identified management measures (i.e., detentions, channel improvements, non-structural improvements, and bridge removals) was systematically tested for performance in fulfilling the additional formulation criteria. In general, the detention opportunities previously identified remained effective and once again, the need for additional flood control improvements were verified. Additional computer model runs tested the alternative channel improvements. Channel improvements were verified as effective in reducing flood damages at specific damage sites. The process of updating management measures next examined bridge removals to determine the systems' response to the systematic removal of various bridges. Some bridge removals actually made the flood problem worse - others were effective in impacting and reducing flood damages. As before, bridge removals were inadequate when used without other measures. Non-structural measures, such as flood plain purchases, were also tested. Low level flood protectors proved to be an effective management measure for addressing the

problem of frequent nuisance flooding and in reducing annual flood damages. Higher levels of flood control were found to be justified on the basis of combined management measure effects.

Summary of Fourth Cycle Iterations

52. Armed with the knowledge that low level flood protectors were very effective in addressing the added formulation criteria, the fourth cycle of plan formulation tested 377 additional alternative plans of improvement including a nonstructural solution, a "traditional" plan and the cycle three "conventional" plan. These plans were carried throughout the last cycle to formulation as a means of insuring the widest possible array of potential alternative solutions in the final selection process. Emphasis was placed on controlling low level flood damages via the least costly solution. Low level flood protection improvements were added to the alternative channel and detention systems to improve performance. In effect, what was discovered was that select channel improvements along with detention and non-structural measures used in specific high damage reaches gave excellent results. To further improve performance, bridge removals were added to the many plans being tested. Some bridge removals reduced damages further. By creating plans of improvement using a combination of detention, channel improvements, low level flood protectors, and select bridge removals, annual flood damages were reduced by an order of magnitude in the range of 85 percent to 93 percent. The plans were then further screened based upon goals, objectives, needs and opportunities. Creation and screening of alternative plans of improvements were accomplished on the basis of the following decision areas: social well-being, regional development, and environmental effects. A special effort to attain higher levels of flood protection is discussed in the paragraphs labeled nominal 100-year plan. Finally all alternative plans were reviewed as

candidates for designation as the NED and EQ plans. A completely nonstructural plan consisting entirely of damageable property relocation was also maintained as a viable alternate through the final selection process.

53. In order to screen alternative plans, the level of detail was kept at a minimum, i.e., costs, benefits, levels of protection, etc. Enough information of screening level quality was used to reject plans which did not meet the previously identified goals, objectives, planning criteria, or constraints. TABLE B-27 illustrates the screening process. Column (1) lists the model run and ensuing plans. For example, 46.2 indicates that this was Plan 2 from computer run number 46. Notice that there are eight plans per computer model run.

54. Column (2) is the first criterion - each reach must have 10-year or greater protection before it will be carried forward to undergo additional screening. This criteria was employed because it was known that much of the annual damages occurred from low level frequent flood events and protection from these frequent nuisance type events would enhance damage reductuion and provide a viable community service. No damage is done to the concept of maximizaton of net tangible benefits by this approach. The word "reject" means that the plan did not meet the criteria and further consideration was not given. A "yes" in the column meant that the given criteria was met and that plan was carried forward for additional screening. In order to reduce the size of TABLE B-27, only those computer runs containing plans that passed the flood protection test are shown. Rejected for lack of adequate flood protection were the 120 plans contained in computer runs 31 through 45, the 16 plans in computer runs 48 and 49, the 24 plans in computer runs 54 through 56, the 24 plans contained in computer runs 60 through 62, the 48 plans in

computer runs 66 through 71, and the eight plans in computer run 75. In summary, the 10-year flood protection screening criteria eliminated 240 of the 374 plans available at this point in the plan reformulation process. Once again, the nonstructural plans and the cycle three "conventional" plan were retained as a means to providing some reasonable diversity in final decision alternatives.

55. Column (3) represents a search for the least possible induced damage. For example, Plan 46.2 passed the level of protection criterion but induced $2,806 damages at the Standard Project Flood (SPF) event and was rejected from further consideration.

56. Column (4) represents a certain minimum B/C ratio. It is believed that a plan must have a BCR of 1.20 at this stage of planning in order to remain viable after a year's cost increase and a change in the discount rate. These criteria were developed to enhance planning efforts and prevent reformulation in the near future. This criteria does not infringe upon the concept and validity of maximization of net tangible benefits.

57. Column (5) is a list of plans which remain after being screened through the first three levels.

58. Column (6) describes the magnitude of the remaining average annual damages. These data were used for additional screening later in the report.

59. Column (7) presents the percent damage reduction based on future conditions without protection. A few of the more favorable plans include 78.2 with a 93 percent damage reduction, 78.3 with a 92 percent damage reduction, and 78.4 with a 91 percent damage reduction.

60. Column (8) reveals the resulting average annual benefits from the plan. As would be expected, the 78 plan model runs produced excellent results.

61. Column (9) is the average annual costs of each plan. Costs included detention, channel improvements, non-structural measures, bridge work, displaced residences, easements, and rights-of-way. Although these initial cost estimates were not all inclusive, they were quite adequate for screening purposes.

62. Finally, Column (10) illustrates the net annual benefits from plans which survived the initial three screening criteria.

63. Columns (5) through (10) did not serve as screening criteria at this phase of plan formulation but did come into play in the following paragraphs to further screen and develop a recommended plan as well as several alternatives.

TABLE B-27
SUMMARY OF UPDATED FORMULATION CRITERIA SCREENING

(1)	SCREENING CRITERIA (2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
PLAN	10-YEAR OR GREATER PROTECTION[1]	PLANS WITH $1000 OR LESS INDUCED (NOMINAL) DAMAGES(AA)[2]	B/C 1.20 MINIMUM CRITERIA[3]	REMAINING PLANS	AVE. ANNUAL DAMAGES REMAIN. ($1000)	PERCENT DAMAGE REDUCTION	AVE. ANNUAL BENEFITS	AVE. ANNUAL COSTS	ANNUAL NET BENEFITS
46.2	Yes	2806 Reject	*	*	*	*	*	*	*
46.3	Yes	2876 Reject	*	*	*	*	*	*	*
46.4	Reject	*	*	*	*	*	*	*	*
46.5	Yes	2816 Reject	*	*	*	*	*	*	*
46.6	Reject	*	*	*	*	*	*	*	*
46.7	Yes	1696 Reject	*	*	*	*	*	*	*
46.8	Reject	*	*	*	*	*	*	*	*
46.9	Reject	*	*	*	*	*	*	*	*
47.2	Reject	*	*	*	*	*	*	*	*
47.3	Yes	2942 Reject	*	*	*	*	*	*	*
47.4	Reject	*	*	*	*	*	*	*	*
47.5	Yes	3754 Reject	*	*	*	*	*	*	*
47.6	Reject	*	*	*	*	*	*	*	*
47.7	Reject	*	*	*	*	*	*	*	*
47.8	Reject	*	*	*	*	*	*	*	*
47.9	Yes	3878 Reject	*	*	*	*	*	*	*
50.2	Reject	*	*	*	*	*	*	*	*
50.3	Yes	1750 Reject	*	*	*	*	*	*	*
50.4	Reject	*	*	*	*	*	*	*	*
50.5	Reject	*	*	*	*	*	*	*	*
50.6	Yes	0	1.32	50.6	719	81	3043	2303	740
50.7	Yes	0	1.33	50.7	620	84	3148	2375	773
50.8	Yes	1228 Reject	*	*	*	*	*	*	*
50.9	Yes	1228 Reject	*	*	*	*	*	*	*

TABLE B-27 (Continued)
SUMMARY OF UPDATED FORMULATION CRITERIA SCREENING

(1) PLAN	SCREENING CRITERIA (2) 10-YEAR OR GREATER PROTECTION[1]	(3) PLANS WITH $1000 OR LESS INDUCED (NOMINAL) DAMAGES(AA)[2]	(4) B/C 1.20 MINIMUM CRITERIA[3]	(5) REMAINING PLANS	(6) AVE. ANNUAL DAMAGES REMAIN. ($1000)	(7) PERCENT DAMAGE REDUCTION	(8) AVE. ANNUAL BENEFITS	(9) AVE. ANNUAL COSTS	(10) ANNUAL NET BENEFITS
51.2	Reject	*	*	*	*	*	*	*	*
51.3	Yes	1560 Reject	*	*	*	*	*	*	*
51.4	Yes	11332 Reject	*	*	*	*	*	*	*
51.5	Yes	12356 Reject	*	*	*	*	*	*	*
51.6	Reject	*	*	*	*	*	*	*	*
51.7	Reject	*	*	*	*	*	*	*	*
51.8	Reject	*	*	*	*	*	*	*	*
51.9	Yes	604 Reject	0.92 Reject	*	*	*	*	*	*
52.2	Reject	*	*	*	*	*	*	*	*
52.3	Yes	490	0.99 Reject	*	*	*	*	*	*
52.4	Reject	*	*	*	*	*	*	*	*
52.5	Reject	*	*	*	*	*	*	*	*
52.6	Reject	*	*	*	*	*	*	*	*
52.7	Yes	236	1.23	52.7	1179	69	2589	2102	487
52.8	Yes	2688 Reject	*	*	*	*	*	*	*
52.9	Yes	5594 Reject	*	*	*	*	*	*	*
53.2	Yes	*	*	*	*	*	*	*	*
53.3	Reject	*	*	*	*	*	*	*	*
53.4	Yes	2228 Reject	*	*	*	*	*	*	*
53.5	Reject	*	*	*	*	*	*	*	*
53.6	Reject	*	*	*	*	*	*	*	*
53.7	Reject	*	*	*	*	*	*	*	*
53.8	Reject	*	*	*	*	*	*	*	*
53.9	Reject	*	*	*	*	*	*	*	*

TABLE B-27 (Continued)
SUMMARY OF UPDATED FORMULATION CRITERIA SCREENING

(1) PLAN	SCREENING CRITERIA (2) 10-YEAR OR GREATER PROTECTION[1]	(3) PLANS WITH $1000 OR LESS INDUCED (NOMINAL) DAMAGES(AA)[2]	(4) B/C 1.20 MINIMUM CRITERIA[3]	(5) REMAINING PLANS	(6) AVE. ANNUAL DAMAGES REMAIN. ($1000)	(7) PERCENT DAMAGE REDUCTION	(8) AVE. ANNUAL BENEFITS	(9) AVE. ANNUAL COSTS	(10) ANNUAL NET BENEFITS
57.2	Reject	*	*	*	*	*	*	*	*
57.3	Reject	*	*	*	*	*	*	*	*
57.4	Reject	*	*	*	*	*	*	*	*
57.5	Reject	*	*	*	*	*	*	*	*
57.6	Reject	*	*	*	*	*	*	*	*
57.7	Reject	*	*	*	*	*	*	*	*
57.8	Reject	*	*	*	*	*	*	*	*
57.9	Yes	2024 Reject	*	*	*	*	*	*	*
58.2	Reject	*	*	*	*	*	*	*	*
58.3	Yes	8862 Reject	*	*	*	*	*	*	*
58.4	Reject	*	*	*	*	*	*	*	*
58.5	Yes	8090 Reject	*	*	*	*	*	*	*
58.6	Yes	9062 Reject	*	*	*	*	*	*	*
58.7	Reject	*	*	*	*	*	*	*	*
58.8	Yes	7898 Reject	*	*	*	*	*	*	*
58.9	Yes	9264 Reject	*	*	*	*	*	*	*
59.2	Reject	*	*	*	*	*	*	*	*
59.3	Reject	*	*	*	*	*	*	*	*
59.4	Reject	*	*	*	*	*	*	*	*
59.5	Yes	5910 Reject	*	*	*	*	*	*	*
59.6	Yes	1600 Reject	*	*	*	*	*	*	*
59.7	Yes	1912 Reject	*	*	*	*	*	*	*
59.8	Yes	5012 Reject	*	*	*	*	*	*	*
59.9	Yes	2024 Reject	*	*	*	*	*	*	*

TABLE B-27 (Continued)
SUMMARY OF UPDATED FORMULATION CRITERIA SCREENING

(1)	SCREENING CRITERIA (2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
PLAN	10-YEAR OR GREATER PROTECTION[1]	PLANS WITH $1000 OR LESS INDUCED (NOMINAL) DAMAGES(AA)[2]	B/C 1.20 MINIMUM CRITERIA[3]	REMAINING PLANS	AVE. ANNUAL DAMAGES REMAIN. ($1000)	PERCENT DAMAGE REDUCTION	AVE. ANNUAL BENEFITS	AVE. ANNUAL COSTS	ANNUAL NET BENEFITS
63.2	Yes	0	1.16 Reject	*	*	*	*	*	*
63.3	Reject	*	*	*	*	*	*	*	*
63.4	Yes	0	*	*	*	*	*	*	*
63.5	Reject	*	*	*	*	*	*	*	*
63.6	Reject	*	*	*	*	*	*	*	*
63.7	Yes	0	1.26	63.7	1189	68	2579	2044	535
63.8	Reject	*	*	*	*	*	*	*	*
63.9	Reject	*	*	*	*	*	*	*	*
64.2	Reject	*	*	*	*	*	*	*	*
64.3	Reject	*	*	*	*	*	*	*	*
64.4	Yes	1074 Reject	*	*	*	*	*	*	*
64.5	Yes	766	1.18 Reject	*	*	*	*	*	*
64.6	Reject	*	*	*	*	*	*	*	*
64.7	Reject	*	*	*	*	*	*	*	*
64.8	Yes	1030 Reject	*	*	*	*	*	*	*
64.9	Yes	1068 Reject	*	*	*	*	*	*	*
65.2	Reject	*	*	*	*	*	*	*	*
65.3	Reject	*	*	*	*	*	*	*	*
65.4	Yes	2274 Reject	*	*	*	*	*	*	*
65.5	Yes	766	1.11 Reject	*	*	*	*	*	*
65.6	Reject	*	*	*	*	*	*	*	*
65.7	Reject	*	*	*	*	*	*	*	*
65.8	Reject	*	*	*	*	*	*	*	*
65.9	Reject	*	*	*	*	*	*	*	*

64. Using the information accumulated thus far, the following plans shown in TABLE B-28 passed the updated formulation screening test.

TABLE B-28
PLANS PASSING UPDATED FORMULATION CRITERIA

	Model Run	Plan
1.	50	6
2.	50	7
3.	52	7
4.	63	7
5.	72	2
6.	72	3
7.	72	4
8.	72	5
9.	72	6
10.	72	9
11.	74	2
12.	74	5
13.	74	6
14.	78	2
15.	78	3
16.	78	4

65. All alternative plans were also analyzed in terms of social well-being, regional development and environmental performance. A summary of these analyses is presented in the following paragraphs.

66. Summary of Updated Formulation Criteria Decisions. The updated formulation criteria presented in TABLES B-27 and B-28 provided rationale for identification of the selected plan of improvements. This final decision process is discussed later in this report under the heading "Rationale for Selected Plan."

Social Well-Being Decisions

67. Section 122, Public Law 91-611, establishes guidelines for assessing economic, social, and environmental effects of civil works projects. These guidelines are designed to ensure that all

significant adverse and beneficial effects of proposed projects are fully considered. Effect assessment is an integral part of the planning process. It serves as one test of the adequacy of that process and of any resulting positive or negative recommendations. It is fully compatible with multi-objective and multi-disciplinary planning. Effects assessment is an iterative process which consists of the following steps: identification of anticipated project-caused economic, social, and environmental effects; quantitative and qualitative description and display of the effects; evaluation of the effects, whether adverse or beneficial; and consideration of measures to be taken if a proposed project would cause adverse effects.

68. All alternative plans were screened for social well-being effects based on the generalized information available and are on file in the St. Louis District Urban Studies office for inspection. TABLE B-29 lists only the 16 plans passing the updated formulation criteria. The variables marked with an asterisk denote items specifically mentioned in Section 122 of Public Law 91-611. The NS plan (nonstructural 100-year flood plain relocation) is also shown.

69. Noise. Column (1) of TABLE B-29 contains information about the level of noise which might be generated by civil works construction activity. The data were drawn from a book entitled Environmental Impact Assessment, written by Larry Canter. TABLE B-30 is a reproduction of the table found in Canter's book. The information for the 16 alternative plans displayed in TABLE B-29 was generated by examining all plans for the type of construction which might take place upon actual implementation of that plan. It was discovered that all the plans would incorporate the same basic equipment and construction techniques: ground clearing, excavation, foundations, erections, and finishing. As a reference point, it should be noted that the average suburban neighborhood experiences

about 65 dBA's. Civil works construction, such as flood control, highways, and sewer construction, generates an average of 85 dBA's. In implementing flood control projects, channel work is usually noisiest, followed by levees and flood walls. A value of 85 dBA's was used to describe the noise levels associated with channel work because such construction employs more excavation - the noisiest of construction activity aside from dynamiting and pile driving. All plans developed used some excavation, but those which tended to be channel intensive received a rating of 85 dBA's and those which minimized channel work in favor of greater non-structural components received a rating of 84 dBA's. Due to the number of plans, some subjective judgment was used in determining the "breaking point" between channel intensive and non-structural intensive. Most were fairly clear-cut.

70. The value of 85 dBA's was developed by taking the average value of (I) - under "Public Works" - in TABLE B-29. The value of 84 dBA's was developed by taking the average value of (I) in the table minus excavations. As is apparent, there is little difference in noise levels generated among the alternatives. It should be noted that these values represent the relatively short-term impacts of construction relative to the 100-year project life.

71. Displacements. Column (2) measures the impact of each of the alternatives on the number of homes displaced by project construction and land requirements. To generate these numbers, aerial photos were used and rough estimates were made concerning expected channel work, non-structural components adopted, and the overall extent of construction work. Some plans were extensive in that the main stem and tributaries would undergo massive work requiring the displacement of a large number of homes. Others were less extensive and demanded fewer displacements. The following values were adopted:

TABLE B-29
SOCIAL WELL-BEING IMPACT ANALYSIS

PLAN	(1)* Noise Levels dBA's	(2)* Homes Displaced	(3)* Aesthetic Value	(4) Housing Quality	(5) Archae-ological	(6) His-toric	(7) Transpor-tation	(8) Educa-tion	(9) Leisure	(10) Cultural Values	(11)* Comm. Cohesion	(12)* Regional Growth	(13)* Inst.	(14) Health, Safety & welfare
50.6	85	75	NJ	N	N	N	N	N	272.7	N	81	H	9	72
50.7	85	75	NJ	N	N	N	N	N	272.7	N	84	L	9	64
52.7	85	165	NJ	N	N	N	N	N	272.7	N	68	H	9	78
63.7	84	165	NJ	N	N	N	N	N	272.7	N	68	M	9	83
72.2	84	75	NJ	N	N	N	N	N	272.7	N	81	L	9	65
72.3	84	75	NJ	N	N	N	N	N	272.7	N	80	L	9	69
72.4	84	75	NJ	N	N	N	N	N	272.7	N	81	L	9	72
72.5	84	75	NJ	N	N	N	N	N	272.7	N	80	L	9	72
72.6	84	75	NJ	N	N	N	N	N	272.7	N	80	L	9	69
72.9	84	75	NJ	N	N	N	N	N	272.7	N	81	L	9	69
74.2	84	165	NJ	BO	N	N	N	N	272.7	N	89	M	9	56
74.5	84	165	NJ	BO	N	N	N	N	272.7	N	89	M	9	57
74.6	84	165	NJ	BO	N	N	N	N	272.7	N	88	M	9	64
78.2	84	165	NJ	N	N	N	N	N	272.7	N	93	M	9	48
78.3	84	165	NJ	N	N	N	N	N	272.7	N	92	M	9	50
78.4	84	165	NJ	N	N	N	N	N	272.7	N	91	M	9	41
NS(1)	89	2,527	NJ	N	N	N	N	N	272.7	N	80	M	10	0

N = NO CHANGE WO = WORSE OFF BO = BETTER OFF
NJ = NO JUDGMENT ID = INSUFFICIENT DATA

(1) NS is the nonstructural 100-year flood plain relocation plan carried throughout the analysis.

TABLE B-30
TYPICAL RANGES OF ENGERGY-EQUIVALENT NOISE LEVELS
IN dBA AT CONSTRUCTION SITES

Phase	Domestic housing		Office building, hotel hospital, school, public works		Industrial parking garage, religious amusement and recreations, store, service station		Public works roads, and highways, sewers, and trenches	
	I[a]	II[b]	I	II	I	II	I[c]	II
Ground clearing	83	83	84	84	84	83	84	84
Excavation	88	75	89	79	89	71	88	78
Foundations	81	81	78	78	77	77	88	88
Erection	81	65	87	75	84	72	79	78
Finishing	88	72	89	75	89	74	84	84

[a]I, all pertinent equipment present at site.
[b]II, minimum required equipment present at site.
[c]I, column used to evaluate noise levels for Maline Creek.

(1) If a plan incorporated substantial main stem construction work with some non-structural components, between 70 and 80 homes would be displaced. The average value is 75 displacements.

(2) If a plan was comprehensive in channel work on the main stem and tributaries, between 150 and 180 homes would be displaced. The average number of displacements in this case was 165 homes.

(3) If a plan used channel improvements conservatively with little or no other measures, between 50 and 60 homes would be displaced for an average of 55.

72. All plans fell into one of these categories. Again professional judgment played a role in assessing the alternative plans. This process produced a good deal of variability between model runs and alternative plans, making screening for social well-being a simpler task.

73. Aesthetic Value. Column (3) contains no measure of aesthetic value. Aesthetic value is construed to be an externality or amenity which varies with personal preferences, tastes, and desires. For example, nearly all plans formulated create recreation areas, fish ponds, and environmental areas which might be pleasantly aesthetic to some. Others see the recreation and environmental areas as generating added neighborhood noise and vandalism potential. These trade-offs cannot be valued without measuring personal utility. No judgment will be made as to the "good" or "bad" of the aesthetics of a Maline Creek project. Public acceptability of a plan serves to judge its aesthetic values.

74. Housing. Column (4) expresses a professionally determined qualitative assessment of expected impacts of each alternative on the housing surrounding Maline Creek. Most of the housing adjacent

to the creek is typical of the housing in the St. Louis, Missouri - Illinois Standard Metropolitan Statistical Area (SMSA). The following served as the criteria for determining if a plan made the housing situation better off.

(1) The greater the degree of protection a plan provided, the greater would be housing stability via maintenance and flood damage reports.

(2) The greater the degree of protection a plan affords, the greater the likelihood of increased housing value.

(3) Higher degrees of protection would reduce flood insurance costs.

75. The potential negative impacts of each alternative would come from such sources as:

(1) Some unsightly structural and non-structural improvements may be visable to a few residents.

(2) If a plan induced substantial damages, then housing values and neighborhood quality would decline.

The trading off of these positive and negative effects is subjective. Each plan was reviewed with these criteria in mind and the impact on housing was given a qualitative rating of "BO" meaning better off or "WO" meaning worse off. As TABLE B-29 indicates, most plans would make housing better off for one or more of the reasons mentioned. In order to be classified as "BO" a 70 percent damage reduction was required.

76. Archaeological, Historic and Transportation. Columns (5), (6), (7) and (8) indicated that none of the alternative plans are expected to have any impacts on archaeological sites, historic sites, transportation or education. There are historic sites within the Maline Creek basin as shown on PLATE A-8, but none are impacted by the plans investigated.

77. Transportation will probably be disrupted due to road relocations and bridge replacements, but this is regarded as a short-term problem and off-set by the fact that the new roads and bridge will be of better quality than the older existing roads. Further, flood protection will prevent damages to some roads which were not protected under the "no project" conditions. There are no known impacts on education.

78. Leisure. Column (9) is the expected impacts each plan would have on leisure. Detention sites would provide for 231,700 user days annually and linear parks would attract another 41,000 visitor days annually. In total, any plan which employed both detentions and linear parks would create 272,700 annual user days of leisure opportunity. This information was used to analyze the impacts on leisure activities of each alternative. As is apparent from scanning this column, most plans used the same basic detention configuration and adopted much of the same linear park outline.

79. Cultural. Column (10) provides a look at the impact each alternative has on cultural opportunities. There are no expected impacts on this parameter.

80. Cohesion. Column (11) measures the impact on community cohesion. The basic premise is that citizens would feel that their Federal, state and local governments are responding to their needs if something is done about their problems. The more that is

accomplished, the greater the utility of cohesion. They would tend to feel that "the system works and they had a role and voice in government." Using this approach, the greater the degree of flood damage reduction and the greater the geographic coverage of the alternative plan, the more satisfied was the community. In short, cohesive strength was construed to be related to the percent reduction in average annual damages. The numbers in Column (11) are the percent average annual damage reduction figures.

81. Growth. Community growth is another variable needing investigation. The costliness and geographic scope of a plan served to measure its potential impact on community growth. Of the three basic measures employed (channel improvements, detentions, and non-structural components), channel improvements proved to be the most costly item. Detentions and non-structured measures followed. Each of the alternative plans were examined to determine which ones were channel intensive, which included dententions, and which used non-structural elements. The relative intensity of use led to a classification of plans which would produce high growth potential, medium growth, or low growth impact. Those plans which were channel intensive or used all three measures received an "H" for high growth stimulus. Those mixing some channel work, detentions, and non-structural received an "M" for moderate growth impacts. Finally, those plans which used few channel improvements and relied on detentions and non-structural inputs received an "L" for low growth plans. The idea used is that the more costly alternatives (H) would lead to greater regional expenditures for construction, and operations and maintenance thereby inducing regional growth via the first cost expenditures and subsequent multiplier effects. A summary of the results are provided in TABLE B-29.

82. Institutional. Institutional analysis is another requirement of Section 122. In this report, the impacts on institutions went

unquantified because no changes in institutional structure are expected to occur. Column (13) is what resulted. All alternative plans would require the same institutional interaction and involvement from nine basic agencies as follows:

(1) 24 municipalities and local governments
(2) St. Louis County
(3) Fish and Wildlife
(4) Vested lobbies
(5) Environmental Protection Agency
(6) The State of Missouri
(7) The general public
(8) Metropolitan Sewer District

83. Health, Safety, and Welfare. Column (14) shows a measure of health, safety and welfare. These values reflect the percentage of remaining damages after a 100-year flood event. The greater these values are, the higher the risk to health, safety, and welfare. For example, if a 100-year event produced $100,000 in damages without protection and $60,000 in damages with protection, the plan was on 40 percent effective in reducing 100-year event damages leaving 60 percent damages remaining.

84. Summary of Social Well-Being Decisions. The social well-being decision information presented in summary form in TABLE B-29 provided rationale for identification of the selected plan of improvements. This final decision process is discussed later in this report under the heading "Rationale for Selected Plan."

Regional Development Decisions

85. In order to maintain consistency and continuity during the screening process, the Regional Development (RD) analysis employed

the same technique for eliminating undesirable plans and focused in on alternatives which fulfilled the criteria established earlier. As before the information developed for the RD screening of all alternative plans is in a general form and available for inspection at the St. Louis District Urban Studies Section. Details of the 16 alternatives passing the updated formulation criteria are presented in TABLE B-30-A. Also shown is the 100-year flood plain nonstructural plan.

86. Tax Revenue. Column (1) of TABLE B-30-A presents data for gains in tax revenue attributable to the implementation of each alternative. They are values which include tax revenues raised as a result of the construction of each plan and its regional multiplier effect. The values were developed in the following way:

87. The February 1979 issue of the Survey of Current Business states that the weekly earnings per contract construction worker was $312.50 or $16,250 per year.

88. Also the October 1978 issue of Monthly Labor Review (Vol. 101, No. 10) indicates that 38.2 hours of labor are generated for each $1000 of contract construction. The estimated average annual cost of each project was then estimated by categorizing each alternative plan into those plans which were non-structural intensive, channel intensive, or non-structural and channel in combination. Instead of costing out each of the alternative plans, samples were taken which resulted in the following average costs:

Measure was essentially	Mean Average Annual Cost
Non-structural	$ 2,042,000
Channels	4,930,000
Non-structural plus channels	2,676,000

89. Using this data, the following information was generated:

Measure	Estimated First Cost	Man-Days of Work Generated	Man-Years of Work Generated	Worker Income Generated
Non-structural	$29,700,000	141,800	388	$ 6,300,000
Channel	71,700,000	559,800	1,533	24,900,000
Both	38,900,000	342,400	938	15,200,000

90. Using the regional multiplier for OBERS (BEA area 114) of 3.1, primary and secondary incomes generated were developed:

Measure	Worker Income Generated	Multiplier	Total Revenue Generated
Non-structural	$ 6,300,000	3.1	$19,500,000
Channel	24,900,000	3.1	77,200,000
Both	15,200,000	3.1	47,100,000

91. Out of a $.04 sales tax for each dollar spent by the workers, $.01 cent goes to local taxes yielding the following local government revenue increases.

Measures	Tax Revenue Generated
Non-structural	$195,000
Channel	772,000
Both	471,000

This summarizes how the values in Column (1) were developed.

92. Property Values. The property value changes illustrated in Column (2) were developed with the aid of a publication entitled, Analysis of Theories and Methods for Estimating Benefits of Protecting Urban Flood Plains, by Greenberg, Leven, and Schlottmann (1974). In summary, what this report says is that the difference in housing values on and off a flood plain in the Maline Creek Basin is $1,800. To utilize this number, each plan was categorized by the amount of average annual flood damage reduction as indicated below:

Average Annual Damage Reduction Category (%)	-M- Mean Value	Increased Values (M x $1,800) for Flood Plain
0- 33%	16%	$ 288 ($ 300)
34- 66%	50%	900 (900)
67-100%	84%	1,512 (1,500)

The value of homes in the flood plain will increase in direct relation to the percent damage reduction. These values are presented in Column 2 of TABLE B-30-A.

93. Public Facilities. The measure of public facilities as used in this report will focus on the number of detention sites created for public recreation. These are facilities which add to the public's choice of leisure time.

94. Public Services. The column labled Public Services goes hand-in-hand with Public Facilities, with each public facility there is an associated service. In the case of detention sites, the services include recreation such as hiking, fishing, picnicking, and nature study.

95. Employment. The values for employment came from the analysis conducted earlier under Tax Revenues. Column (5) summarizes the results.

96. Business Activity. The values for business activity in Column (6) also came from work done on Tax Revenues. Business revenues included the value of the business or sales created from direct Federal first cost, as well as the ensuing multiplier effects throughout the region.

97. Displaced Farms. As indicated in Column (7) there are no displaced farms associated with any of the alternatives considered.

98. Summary of Regional Development Decisions. The regional development decision information presented in summary form in TABLE B-30-A provided rationale for identification of the selected plan of improvements. This final decision process is discussed later in this report under the heading "Rationale for Selected Plan."

Environmental Effects Decisions

99. These effects are defined as the observable quantitative or qualitative changes in natural phenomena or related man-made resources related to any proposed project. The changes may be of a market or non-market character, but generally the latter. Such effects are inextricably linked to the ongoing economic and social activities of man. Where not amenable to conventional market valuation, these changes may be measured or referred to by a variety of technical attributes, standards, threshold levels, data, and indices. They may be perceived as beneficial or adverse.

100. Ideally, if planning is to be environmentally sound it must begin with a comprehensive ecosystem analysis based on reliable technical surveys. Such surveys would generally define and limit the physical and biological resources in the broadly affected planning area; attempt to identify, analyze, and understand those factors which critically control or affect ecosystem distribution; and arrange the information collected so that system response to both natural and man-made changes can be assessed. Because of the numerous physical and biological factors involved in large-scale water resources planning systems and their complex interactions, a full and complete analysis is constrained by the present state of knowledge and understanding. Since substantial judgments must

TABLE B-30-A
REGIONAL DEVELOPMENT DATA

PLAN	(1) TAX REV. ($10,000)	(2) PROPERTY VALUES $	(3) PUBLIC FACILITIES	(4) PUBLIC SERVICES	(5) MAN-YEARS OF EMPL.	(6) BUS ACT. ($1,000,000)	(7) DISPLACED FARMS
50.6	7.7	1,500	8	8	1,533	77.2	0
50.7	7.7	1,500	8	8	1,533	77.2	0
52.7	4.7	1,500	8	8	938	47.1	0
63.7	4.7	1,500	8	8	938	47.1	0
72.2	4.7	1,500	8	8	938	47.1	0
72.3	4.7	1,500	8	8	938	47.1	0
72.4	4.7	1,500	8	8	938	47.1	0
72.5	4.7	1,500	8	8	938	47.1	0
72.6	4.7	1,500	8	8	938	47.1	0
72.9	4.7	1,500	8	8	938	47.1	0
74.2	4.7	1,500	8	8	938	47.1	0
74.5	4.7	1,500	8	8	938	47.1	0
74.6	4.7	1,500	8	8	938	47.1	0
78.2	7.7	1,500	8	8	1,533	77.2	0
78.3	7.7	1,500	8	8	1,533	77.2	0
78.4	7.7	1,500	8	8	1,533	77.2	0
NS(1)	27.0	0	0	0	10,730	270.2	0

(1) NS is the nonstructural 100-year flood plain relocation plan carried throughout the analysis.

necessarily be applied by planners, participating consultants, and the involved public, a conservative approach that considers the long-term integrity of the environment should generally be followed.

101. Based on the anticipated project-caused changes in the affected ecosystem, this study has described and characterized those which are of ecological significance. Alteration of input of critical physical or biochemical categories by the alternative plans being considered will induce certain changes in the ecology of the associated aquatic and terrestrial environments. However, the complexity and interrelationships of components of each of these systems preclude any simplified definition or classification of effects except in the broad categories set forth in Section 122, i.e., air pollution, water pollution, natural resources, and man-made resources.

102. In essence, changes in the input of critical factors may alter the suitability of the environment for terrestrial and acquatic organisms to carry on basic processes.

103. In general, this analysis identified changes in ecosystem structure and function that significantly affected ecosystem integrity. In general, topics of paramount concern to ecosystems included the maintenance of biogeochemical cycling systems; performance of energy transfer processes; viability of food web relationships; rate and balance of organic production; rate of eutrophication; change in diversity - stability relationships of organisms; and successional relationships.

104. While a full consideration of the above topics is not possible, it would be inappropriate to eliminate any of them from at least a preliminary screening in the effect assessment process.

105. The broad environmental effect categories discussed below are those that are specifically mentioned in Section 122.

106. In consonance with Principals and Standards and Section 122, (Public Law 91-611) and NEPA Public Law 92-500, the following environmental effects were investigated during the screening process.

Environmental Effects

(1) Man-made Resources
(2) Natural Resources
(3) Pollution
 (a) Air
 (b) Water
 (c) Land
(4) Animal and Plant
(5) Ecosystems

107. When analyzing the impacts of each of the alternative plans, these environmental variables served to screen undesirable planning alternatives and focus on finding those plans from which an EQ plan could be selected. Once again the complete analysis for all alternative plans is available for inspection in the St. Louis District Urban Studies Section. TABLE B-31 presents this information for only those 16 plans passing the updated formulation screening criteria. Also shown is the 100-year flood plain relocation nonstructural plan.

108. Man-Made Resources. The chief man-made resources which are common to all alternatives are the detention sites which not only serve the recreation needs of the area but with the inclusion of fish ponds serve to improve the aquatic habitat. Various model runs

TABLE B-31
ENVIRONMENTAL QUALITY PLANNING

	(1)	(2)	(3)			(4)	(5)	(6)
			Pollution Aspects			Animals and		Endangered
PLAN	Man-Made Resources	Natural Resources	Air	Water	Land	Plants	Ecosystems	Species
50.6	8	HEU	HAP	27	1	0	66	None
50.7	8	LEU	LAP	27	2	0	66	None
52.7	8	HEU	HAP	25	3	0	64	None
63.7	8	MEU	MAP	27	1	0	66	None
72.2	8	LEU	LAP	26	2	0	65	None
72.3	8	LEU	LAP	26	2	0	65	None
72.4	8	LEU	LAP	26	2	0	65	None
72.5	8	LEU	LAP	26	2	0	65	None
72.6	8	LEU	LAP	26	2	0	65	None
72.9	8	LEU	LAP	26	2	0	65	None
74.2	8	MEU	MAP	31	2	0	70	None
74.5	8	MEU	MAP	31	1	2	69	None
74.6	8	MEU	MAP	31	1	0	70	None
78.2	8	MEU	MAP	34	1	10	63	None
78.3	8	MEU	MAP	34	1	8	65	None
78.4	8	MEU	MAP	34	1	2	71	None
NS(1)	0	LEU	HAP	30	0	0	71	None

HEU: High Energy Use Plan
MEU: Moderate Energy Use Plan
LEU: Low Energy Use Plan
HAP: High air pollution of a short-term nature is expected
MAP: Moderate air pollution of a short-term nature is expected
LAP: Low air pollution of a short-term nature is expected
(1) NS is the nonstructural 100-year flood plain relocation plan carried throughout the analysis.

used different detention sites: different in terms of size and number. Some plans used no detention and others which were tested used as many as 15 detention sites. The trade-off was between the levels of flood protection but with the environment in mind.

109. Other related man-made resources of an environmental character included grade control/aquatic habitat structures used for bottom flood control and erosion stability and to oxygenate stream flows. Aquatic life in Maline Creek is sparce at best under existing conditions and it is believed that in providing grade control structures the environment would be enhanced.

110. A third man-made resource related to environmental impact was the creation of recreation trails which serve in part for aesthetic recreation opportunities and in part for environmental education.

111. Nearly all plans contained some element of grade control structures and a system of trails. Most alternatives did not differ measurably in the amount or quality in this respect. As such, control structures and a trail system were not discriminatory enough to use as a screening criterion. Consequently, detention sites served as the principle source of variance between alternatives and were used as the main screening variable. A review of the plans also indicated that little or no man-made resources would be destroyed and as such very little or any negative impacts would result.

112. The criteria and philosophy to rank man-made resources and analyze each alternative centered on the notion that the greater the number of detention sites (up to 15) the higher the ranking for man-made resources. Ranking man-made resources was in direct relation to the number of detention sites. If no detention was used

during flood control formulation, the rank of that plan was "0." If 15 sites were used, the rank on a man-made resource base would be "15." The final values are shown in Column (1) of TABLE B-31.

113. Natural Resources. Natural resources for the purpose of this report include the following:

Impacts on Natural Resources

(1) Minerals
(2) Water
  (a) Streams
  (b) Lakes
(3) Energy
(4) Land Form
(5) Erosion of Soil
(6) Air
(7) Human

114. The principles used to evaluate the natural resources variable will be conservation and preservation. This portion of the report will emphasize impacts on minerals, energy, land form, and human resources and will report on water, soil, and air resources under "pollution aspects" to be covered next.

115. The criteria for ranking plans will focus on finding those alternatives which employ the use of the least amount of natural resources which will accomplish the previously stated goals and objectives while meeting the stated constraints and solving the indicated problems and needs. This is really an efficiency criteria.

116. Among the alternatives formulated, some required more resource inputs than others. For example, extensive channel improvements

require the use of a great deal of input (oil, gasoline, manpower, and land form changes). Others such as non-structural measures required less natural resource inputs. Some of these inputs are in the class of renewable resources and others fall into non-renewable resources. Most construction material such as rock, sand, concrete, and steel are renewable with national stock plentiful. Others such as petroleum are in short supply and increasingly expensive. Consequently plans which tend to utilize the non-renewable natural resources are ranked as less desirable. Those which employed fewer energy inputs are ranked as superior alternatives. In separating the alternatives, some professional judgment was used because a number of the alternatives were not easily categorized. The following information was used to rank (qualitatively) the plans:

Energy Use Impact

Plans Making Extensive Use of	Energy Use Rank
Channel Improvements	High Energy Use (HEU)
Non-Structural Improvements	Low Energy Use (LEU)
Some channel and some non-structural improvements	Moderate Energy Use (MEU)

117. A clearer definition of this ranking will facilitate understanding. Extensive use when applied to channel improvements means that channel improvements were the principle source or measure of flood control. Some non-structural measure may have been used but the plan made comprehensive and substantial use of large and medium channel work.

118. The extensive use of non-structural measures means that the plan incorporated as a principal component of flood control non-structural measures. Channel improvements were kept at a

minimum using basically medium to small channel work in select reaches.

119. The extensive use of channel improvements and non-structural elements means that the plan contained a mix of measures with moderate use of channel work coupled with some energy saving non-structural approaches.

120. It should be noted that the energy use criteria is correlated with other natural resource inputs. For example, the greater energy use associated with channel intensive plans usually means that there was a high use of mineral resources, land form changes, energy resources, and human resources. Conversly, an intensive use of non-structural measures is associated with lower mineral resource inputs, land form changes, energy resources, and human resources. Energy as recognized today, is strongly tied with the level of engineering, construction, and the mobilization of manpower.

121. Energy use thusly served as the key ranking criterion. These rankings are illustrated in Column (2) of TABLE B-31.

122. Pollution Aspects. Section 122 also requires an analysis of the impacts of planning alternatives on the pollution of air and water. Included for additional screening is land pollution.

a. Air Pollution. Air pollution comes from one basic source: socio-economic activity. One of the major sources of air pollution comes from the internal combustion engine. In order to qualitatively evaluate the impacts of each alternative, this fact was of key consideration. Those planning alternatives which involved the intensive and widespread use of gasoline or diesel fuels would, at least during the actual construction phase, result in higher-than-normal concentration of local air pollutions.

Consequently, plans which required intensive and wide spread use of such equipment are less desirable in terms of air quality deterioration than those plans which are less equipment intensive and narrower in flood control coverage. Dust pollution also falls into this category. In order to rank plans into air polluting categories it was assumed that plans which are highly construction oriented and high energy users will generate high air pollution problems. Similarly, moderate construction activity and moderate energy consumption plans will generate moderate levels of air pollution. For lower construction activities and lower energy intensive plans, smaller levels of air pollution will occur. This information allowed the ranking of air pollution by alternative as illustrated in Column (3) of TABLE B-31. High Air Pollution (HAP), Moderate Air Pollution (MAP), and Low Air Pollution (LAP) are indicated in the table. These are construed to be short-term construction problems with no long standing environmental effects.

b. Water Pollution. As indicated in the Base Study and Future Conditions Without Protection, the water quality and aquatic habitat are in poor condition at the present time. Implementation of EPA and state/local pollution abatement plans are expected to correct this problem within the next decade. Certain measures in these plans may provide additional pollution control. The plans considered in this last stage of formulation and impact assessment contain such features as detention, ingrade control structures, fish ponds, and some channel coincidental erosion control. In addition, nearly all plans include channel clearing and snagging and related cleanup operations. These measures, although developed for other purposes, would only improve water quality. In developing measures for impact assessment for water quality, the following criteria were used. Some of the alternatives covered many formulation reaches along both the main stem and tributaries. Some required more detention sites than others. As a result of this greater coverage

and detention capacity, water quality is expected to improve through the added detentions, added fish ponds, and added ingrade structures due to the greater coverage of a more comprehensive plan. Other plans impacted fewer reaches on the main stem and tributaries and fewer detentions, fish ponds, and ingrade structures. These would still improve the water quality of the ambient and expected future conditions, but not to the same degree as the more comprehensive plans. There were a few plans which did not incorporate channel measures or extensive use of non-structural components, for example, bridge removals only, selected non-strucural sites, etc. These plans would not lead to fish ponds, grade control structures, and few if any detentions. As a result there would be no improvement of water quality expected from these plans. The ranking of plans with regard to water quality involved the number of reaches receiving some type of improvement. With each reach improvement would be associated with a water quality improvement-drop structure, fish pond, or detention. The highest water quality rank was 40; the lowest was 7. Again some professional judgment had to be employed. The results are presented in Column (3) under "water."

c. Land Pollution. Land pollution includes such problems as erosion, debris, dumps, man-made structures, and mining activities. There are erosion problems along Maline Creek but the problems are not severe nor widespread. Some of these problems will be resolved as channel improvements are installed. Others will be improved by the use of detention and non-structural measures. Debris has been a persistent problem along Maline Creek - especially man-produced trash dumped into the creek. Natural debris is also persistent. A good deal of the existing debris problems will be resolved by many of the alternatives. Clearing and snagging is an integral part of nearly all alternatives. Also the MSD periodically clears problem areas. This aids in reducing the magnitude and scope of debris problems. Debris removal will be part of operation and maintenance

required in the alternatives considered. Dumps and disposal areas are few in Maline Creek. These are a problem in a few select areas under private ownership. While unsightly, they do not constitute a flood problem. Corps of Engineers' channel work includes excavations but the resulting soil removal will be used for measures such as select low level flood protectors. Man-made structures can also be a form of land pollution. Insofar as this study is concerned, some of the flood control measures tested would create this situation. Those plans which did not employ flood walls and levees were ranked as "0" meaning no unsightly man-made pollution was created (see Column (3), TABLE B-31). Those plans that used the non-structural and very small flood protectors - say 1 to 3 feet - received a rating of "1." Similarly, those plans using a medium size levee or flood wall received a rating of "2" - say 3-5 feet. Finally, those structural measures employing large levees or flood walls - between 6-12 feet - were rated as "3," the most unsightly. The details of this analysis are on file in the Urban Studies Section, St. Louis District, Corps of Engineers, for review as necessary.

123. Animals and Plants. This portion of environmental assessment focused on each alternative's impact on animal and plant species. The main thrust was based on habitat destruction/creation. An environmental analysis was conducted which ranked stream reaches in terms of their currently existing environmental quality as shown below. Those measures which tended to adversely disrupt the ambient environmental quality of priority one reaches were considered poor solutions. However, those alternative plans that improved the currently degraded nature of the environment were considered to be superior solutions.

EXISTING ENVIRONMENTAL QUALTIY

Reach	Rank Priority
M1	2
M2	2
M3	1
M4	1
M5	1
M6	1
M7	1
M8	1
M9	1
M10	1
M11	1
M12	1
M13	1
M14	1
M15	1
MD	2
MD1	1
MD2	1
MD1-1	1
MD1-2	1
MH	1
All other reaches	3

124. It was assumed that the construction of large channels in priority one reaches was the most destructive to habitat. Medium channels would be less destructive and small channels least destructive. A reach which required a large channel received a rank of "3," a medium channel ranked "2," a small channel a rank of "1," and no channel work a rank of "0." The greater a plan's rank (higher sums) the more degraded are priority one reaches. The smaller a plan's rank (lower sums) the less are construction impacts. A perfect plan - one which had no impacts on priority one reachs would have a sum of "0." A highly destructive plan would have a maximum rank of "39." These are the extremes. Bridge removals or alternations received a "0" rank because there would be little or no induced habitat destruction. It should also be remembered that habitat destruction is due to construction - not future conditions with or without a project. Future conditions without a project will lead to environmental degraditon from urbanization but are likely to improve with a project.

125. Ecosystems. Charles Krebs in <u>Ecology</u>, describes an ecosystem as, "a biotic community and its abiotic environment." As described earlier, the ambient ecology of the Maline Creek watershed is poor at best and shows signs of continued degredation under the stress of urbanization. Alternative plans with environmental considerations could stop this degradation and quite possibly reverse and improve the adverse trends. Some plans would do this better than others. Most plans would utilize grade structures, fish ponds, detentions, and preserved high quality environmental areas through fee simple purchase. The more comprehensive the plan, the more such features would be used. This idea was used to rank ecosystem improvements. Ecosystems would in essence be created or preserved by each plan and the more extensive the plan the greater would be ecosystem creation. All plans were reviewed with this concept in mind. The ranking of the impact on ecosystem parallels that of water quality

improvements discussed earlier. The added feature is terrestrial habitat. During the analysis of water quality, plans were ranked according to the number of reaches receiving protection, the idea being that with each reach improvement was associated a water quality improvement, i.e., fish pond, grade control structures, and detention. This analysis also makes the realistic assumption that with each reach improvement terrestrial habitat would also be preserved by actions taken by the Corps. This requires in addition that any given measure in-and-of itself does not require habitat destruction through construction actions (TABLE B-31, Column 4: animal and plant). To accomplish the task of ranking for ecosystems the following procedures were used.

126. The greater the number in Column (3) (Water Pollution) the better the plan was. The greater the number in Column (4) (Animal and Plant) the worse the plan was. The highest rank in Column (4) was 39. If the value in Column (3) under water quality was added to the value in Column (4) minus 39, an index would be formed which incorporates the positive aspects of water quality improvements with the positive aspects of habitat preservation. For example: Plan (31.2) says that there are 19 reaches which would receive flood control improvements and thusly 19 water quality related improvements. The greater the number in this column, the better is water quality improvements. The highest value for this column of any plan was 40. The larger the number in Column (4), Animal and Plant, the greater the adverse impact on habitat of construction activity. The lower this value, the greater are the positive impacts on habitat - they are preserved. The maximum negative impact value is 39. Thus:

$$19 + (39 - 13) = 45 \text{ for plan } (31.2)$$

The larger this value is, the greater will be aquatic and terrestrial habitat preservation and enhancement. The results are presented in Column (5). The highest rank was 71.

127. Endangered or Threatened Species. A careful field investigaton and resource inventory has indicated that there are no endangered or threatened species in the Maline Creek Basin (Column (6), TABLE B-31).

128. Summary of Environmental Effects Decisions. The environmental effects decision information presented in summary form in TABLE B-31 provided the rationale for identification of the selected plan of improvements. This decision process is discussed later in this report under the heading "Rationale for Selected Plan."

Nominal 100-Year Plan

129. It was recognized from the beginning of this study and has been repeatedly verified, that the fundamental water and related land resource problems of Maline Creek are basic flood control problems. The magnitude of the average annual damages ($4,145,000) also attests to the serious need for effective flood damage reduction measures. In order to insure that every possible means for reducing the severity of the flood damages had been addressed, two additional opportunities to provide 100-year flood protection were explored. One of these opportunities focused on nonstructural 100-year protection and the other on structural protection. The 100-year performance level was selected so as to accommodate the Federal Insurance Administration's (and now FEMA, Federal Emergency Management Agency) selection of 100-year floodway approximations for their regulatory program emphasis.

130. Nonstructural 100-Year Plan. The opportunity to prevent all damages occurring within the 100-year flood plain area via complete relocation was considered. Under existing conditions (1977) there are 2,527 homes plus 56 commercial structures located in the 100-year flood plain area. An initial very conservative estimate of the cost to purchase and relocate 2,527 homes plus 56 commercial establishments indicated expenditures would be in excess of 150 million dollars. The average annual cost of the nonstructural 100-year flood plain relocation plan is estimated to be approximately $21,290,000 (at 6-7/8%) exclusive of costs to relocate public facilities (i.e., roads, sewers, sidewalks, telephone lines, etc.). This high cost plus the undesirable social disruption of moving 2,527 families precluded further consideration of this opportunity to provide 100-year flood damage prevention. Protection for higher frequency floods via nonstructural solutions was even less viable.

131. Structural 100-Year Plan. The second opportunity pursued for improving flood control performance to the 100-year level was the identification of a nominal structural 100-year plan. A search of all alternative plans was made to identify any plans that could provide protection against a 100-year flood event. Also specifically noted was any possibility that Standard Project Flood (SPF) protection might be technically possible (protection at 500-year or greater levels). Of the complete range of technically possible plans studied, only one could be identified as providing nominal protection against a 100-year flood.

132. The nominal 100-year structural plan used the most extensive channel sizes reasonably possible in combination with flood walls ranging in height from 12 feet to 15 feet, plus basic detention site flood reductions. No combination of large channels and flood walls could be found which provided complete protection against the

100-year flood event. The alternative most closely approximating 100-year frequency protection was found in plan 39.9. TABLE B-32 shows the details of this alternative.

133. As TABLE B-32 illustrates, protection against an SPF event was achieved in 18 reaches where benefits might marginally exceed costs. The multi-plan model run indicated that this plan could only provide SPF protection to 17 of these 18 reaches. No attempt was made on the remaining 15 reaches because costs always exceeded benefits by a wide margin. In addition, it was reasoned that if the profiles could be lowered on the main stem reaches, it would follow that the profiles of tributary reaches would fall also. This reasoning proved to be correct. Nine of the 15 unprotected reaches indicated water surface profile improvements and subsequent damage reductions. The water surface profile fall in the protected main stem reaches led to lowered water surface elevations in the unprotected reaches and resulted in $162,000 annual benefits without any additional annual costs. In total, 17 out of 33 reaches could be protected against the SPF flood event. As indicated in TABLE B-32, average annual flood control benefits from this plan amounted to $3,649,000.

134. The next step in the process was to investigate annual costs. Four cost components were examined including: 1) flood wall elements, 2) channel costs, 3) bridge costs, and 4) easements and rights-of-way. It became obvious at this point that annual costs greatly exceeded annual benefits. Total costs are $10,197,000. The resulting BCR is 0.36. It was clear that no further analysis was needed. A decision was made to discontinue searching for potential 100-year as well as SPF flood event protection. Items not included in this search for higher flood protection performance that would further increase costs were: 1) an interior drainage system for handling water accumulating behind the walls during a severe storm,

TABLE B-32
NOMINAL 100-YEAR PLAN
PLAN 59.9 COMPONENTS
7-1/8%

Seq. No. Multi-Plan (1)	Channel Reach (2)	Measure (3)	No.Plan Damage (4)	Berm Cost (5)	Channel Cost (6)	Bridge Cost (7)	Buyouts (8)	Easement Rt./Way (9)	Total Cost (10)	Benefits (11)	Degree Protection (12)	B/C (13)	Ind. Damage (14)
4	M16	EMN8	131	73	76	43	-	7	199	131	SPF	.66	-
5	M15	EMN6	20	50	59	52	-	5	166	20	SPF	.12	-
7	MH	-	35	-	-	16	-	-	16	18	2	1.13	-
8	M14	EMB8	70	59	67	13	-	6	145	70	SPF	.48	-
9	M13	ELH8	94	75	81	-	-	7	163	94	SPF	.58	-
10	M12	ULN8	615	69	487	-	-	7	563	615	SPF	1.09	-
11	MG2	ULN8	530	44	217	-	-	4	265	530	SPF	2.00	-
12	MG1	ULN8	18	37	207	12	-	4	260	18	SPF	.07	-
N/A	MF2	-	6	-	-	-	-	-	-	-	2	-	-
N/A	MF1	-	3	-	-	-	-	-	-	1	5	-	-
15	M11	ULN8	314	37	487	13	-	4	541	314	SPF	.58	-
17	M10	ULN8	219	74	771	-	-	7	852	219	SPF	.26	-
18	M9	ULN8	99	77	795	12	-	7	891	99	SPF	11	-
19	M8	ULN8	395	75	819	33	-	7	934	395	SPF	.42	-
20	M7	ULN8	7	55	600	16	-	5	676	7	SPF	.01	-
21	M6	ULN8	197	88	860	-	-	8	956	197	SPF	.21	-
23	MD6	-	14	-	-	-	-	-	-	14	2	-	-
24	MD5	-	47	-	-	-	-	-	-	23	2	-	-
26	MD4	-	35	-	-	-	-	-	-	18	2	-	-
28	MD3	-	51	-	-	-	-	-	-	10	2	-	-
32	MD1-3	-	-	-	-	-	-	-	-	-	100	-	-
33	MD1-2	-	55	-	-	-	-	-	-	21	2	-	-
34	MD1-1	-	4	-	-	-	-	-	-	2	5	-	-
35	M32	-	136	-	-	-	-	-	-	45	2	-	-
36	MD1	-	24	-	-	57	-	-	57	10	2	.18	-
38	M5	ULN8	594	85	420	47	-	8	560	594	SPF	1.06	-
39	M4	ULN8	68	31	446	36	-	3	516	68	SPF	.13	-
43	MC	-	121	-	-	11	-	-	11	-	2	-	-
44	M3	ULN8	67	56	573	-	-	5	634	67	SPF	.11	-
47	MB	-	22	-	-	10	-	-	10	-	2	-	-

TABLE B-32 (Continued)
NOMINAL 100-YEAR PLAN
PLAN 59.9 COMPONENTS
7-1/8%

Seq. No. Multi-Plan (1)	Channel Reach (2)	Measure (3)	No.Plan Damage (4)	Berm Cost (5)	Channel Cost (6)	Bridge Cost (7)	Buyouts (8)	Easement Rt./Way (9)	Total Cost (10)	Benefits (11)	Degree Protection (12)	B/C (13)	Ind. Damage (14)
49	M2	ULN8	26	95	1083	24	-	9	1211	26	SPF	.02	-
50	MA	-	89	-	-	36	-	-	36	-	2	-	-
52	M1	RNB7	39	48	-	-	-	4	52	23	10	.44	757
			4145	1128	8048	431	-	107	9714	3649		-	757
	DET.SITE						CONFIGURATION						
1	M27	1,3	-	-	-	-	-	-	73		-	-	-
3	M22	1,3	-	-	-	-	-	-	40		-	-	-
6	MH1	2,1	-	-	-	-	-	-	57		-	-	-
13	MF1	2,1	-	-	-	-	-	-	38		-	-	-
14	MF2	3,1	-	-	-	-	-	-	66		-	-	-
16	M13	-	-	-	-	-	-	-	-		-	-	-
22	MD-1	3,5	-	-	-	-	-	-	78		-	-	-
25	MD2-2	1,3	-	-	-	-	-	-	54		-	-	-
27	MD-2	-	-	-	-	-	-	-			-	-	-
29	MD1-1	1,3	-	-	-	-	-	-	77		-	-	-
30	MD1-2	-	-	-	-	-	-	-	-		-	-	-
40	MD-1	-	-	-	-	-	-	-	-		-	-	-
41	MD-2	-	-	-	-	-	-	-	-		-	-	
45	MB-1	-	-	-	-	-	-	-	-		-	-	-
46	MB-2	-	-	-	-	-	-	-	-		-	-	-
									483				

Benefits	3649
Costs	10197
Net Ben	(6496)
BCR	.36
% Dam.Red.	88%

2) closure structures, 3) residential relocations, and 4) sewer modifications. These would only add additional costs to the plan.

135. The plan illustrated in TABLE B-32 was considered a nominal 100-year plan because only $331,000 in damages from the 100-year frequency event still remained. Further, a SPF flood event would cause a devastating $28,170,000 in damages. While $331,000 may not be considered devastating, it was felt that $28,170,000 in damages would fall under the heading of a catastrophe. The plan also induced downstream damage of $756,000 from a SPF flood.

136. The nominal 100-year plan possessed additional adverse characteristics. These included: 1) the need for closure structures, 2) interior drainage, 3) residential relocations, 4) sewer modifications, 5) aesthetically unpleasant, 6) environmentally destructive, and 7) a safety trap. Some of these characteristics were briefly mentioned earlier, but a more descriptive analysis is required.

137. Closure structures are not only costly but impractical in an urban area. Someone would have to be assigned the responsibility of operating the gates and essentially be on a 24-hour alert. The predictability of a large damaging storm is guess work to a large extent. The reliability of radar, satelites, and other detecting equipment is not 100 percent accurate. There would be false alarms, misforecasts, and confusion. In an urban area these circumstances could be costly and dangerous.

138. Interior drainage would be simply too expensive. Given a BCR of 0.36, a drainage network consisting of pumps, pondage, and gravity drains would only reduce the BCR further. The nominal 100-year protection plan would require a high concrete wall. During a 100-year frequency storm, it may not be possible to pump flood

water from [illegible] the wal[illegible] gravity [illegible] would [illegible] conditions.

[illegible] the [illegible] of [illegible] a [illegible] deal of [illegible] the [illegible] w[illegible] [illegible] changes [illegible] is also [illegible] leaving [illegible] from their homes [illegible] neighborhood integrity and [illegible]

[illegible] design [illegible] other util[illegible] be required [illegible]

[illegible]-foot [illegible] back water [illegible]

[illegible] unders[illegible] There are a few good [illegible] Moline wat[illegible]. The construct[illegible] and high concrete walls would [illegible] destruction [illegible] remaining [illegible] areas [illegible]

clearing would be required. This would be unacceptable environmentally.

143. The plan is a safety trap. If a SPF flood event occurred with 100-year protection, up to $28,170,000 event damage could result. A flood of this magnitude would be destructive to homes, industry, utilities, and may cause loss of life.

144. To summarize, the 100-year frequency plan is simply not viable. The following problems are apparent:

a. the BCR = 0.36 (does not include all costs),
b. the plan is a safety trap,
c. the plan is environmentally destructive,
d. the plan is aesthetically displeasing,
e. the displacement of people is substantial,
f. the plan induces $756,800 during a 500-year flood event,
g. the plan has $331,000 remaining damages at the 100-year event,
h. the plan protects only 17 out of 33 reaches,
i. the plan would require the purchase of large tracts of land,
j. the potential exists for $33,100,000 in SPF event damages,
k. Bridge modifications would be extensive,
l. A 24-hour team would be needed to operate closure structures.

145. Because of these over-whelming factors, further consideration of high levels of protection was discontinued.

Nonstructural Plan

146. In searching for a nominal 100-year plan, testing was made on a nonstructural plan that would relocate all flood damageable

structures (some 2,527 homes plus 56 commercial establishments) out of the Maline Creek 100-year flood plain area. That alternative plan was found to be significantly unjustified and dismissed without any practical need to pursue all the major social disadvantages of such a sizeable population relocation. However, every possibility that the "nonstructural" relocation alternative might be realistic was pursued because of the technically attractive concept of simply moving the damageable items out of harms way. In some instances, relocation seems to be immediately and thoughtlessly favored by non-flood plain residents who do not realize it is their very development that causes much of the increased storm water runoff problem that builds up and cascades down upon innocent downstream property owners. Casual analysis, or possibly no analysis at all, seems to mislead some agencies and individuals into the mistaken notion that relocation of existing development is somehow a flood damage reduction panacea. As more professional studies are completed, it is becoming increasingly clear that relocation is economically a rather poor solution, suited to relatively uninhabited flood plain areas. Intensely urbanized areas faced with hundreds or thousands of flood plain structures normally must seek out some more reasonable alternative. The reasonableness of a relocation program limited to just those structures located within the 10-year flood plain area was analyzed. This nonstructural alternative consisted of purchase in fee simple and relocation of all damagable property in the 10-year flood zone. To implement this plan would require the purchase of 1,392 residential structures and 31 commercial establishments. The advantages to this alternative are as follows:

1. The structures would no longer be subject to flood damage.

2. Security to life and property would be directly improved.

3. Average annual flood damage would be reduced by $3,477,600.

4. The average annual savings of insurable costs, administrative costs, and flood fight costs would be $807,900.

The disadvantages are as follows:

1. Annual damages to the flood plain above the 10-year level would continue.

2. This nonstructural plan would cause a very major social disruption, family relocation and community instability impact.

3. Implementation of this plan would cost a minimum of $12,073,500 annually.

4. The benefit to cost ratio for a nonstructural solution is a very poor 0.07. That is, for every dollar that might be invested in this nonstructural solution, only $.07 would be gained.

147. It is clear from an economic, regional development, and social well-being point of view, that this alternative is improbable and not worthy of implementation. TABLE B-33 provides the details of estimated costs and TABLE B-34 shows expected annual benefits.

Traditional Plan

148. The performance of a plan which utilized only traditional flood control management measures (i.e., channel improvements only) was tested. The performance goal set for this "traditional" plan was to protect against the 10-year flood event, similar to the goal set for the nonstructural plan. The creation and testing of a flood

TABLE B-33
ESTIMATED REAL ESTATE COSTS 1/ 2/
10-YEAR FLOOD ZONE - 7-1/8%

Reach	No. of Homes	No. of Comm.	Annual Cost of Homes	Annual Cost of Comm.	Total Annual Cost of Homes & Comm.
M1	5	0	$ 39,100	$ 0	$ 39,100
M2	18	0	140,900	0	140,900
M3	40	0	313,000	0	313,000
M4	28	0	187,800	0	187,800
M5	0	2	0	78,300	78,300
M6	135	0	1,055,300	0	1,055,300
M7	5	0	39,100	0	39,100
M8	298	0	2,332,000	0	2,332,000
M9	46	0	360,000	0	360,000
M10	34	1	266,100	39,100	305,200
M11	99	0	774,700	0	774,700
M12	128	24	1,001,700	939,100	1,940,700
M13	57	0	466,100	0	466,100
M14	60	0	469,500	0	469,500
M15	37	0	289,500	0	289,500
M16	63	0	493,000	0	493,000
MA	44	0	344,300	0	344,300
MB	19	0	148,700	0	148,700
MC	46	0	360,000	0	360,000
MD1	18	0	140,900	0	140,900
MD2	63	0	493,000	0	493,000
MD3	24	0	187,800	0	187,000
MD4	13	0	101,700	0	101,700
MD5	23	0	180,000	0	180,000
MD6	9	0	70,400	0	70,400
MF1	2	0	15,700	0	15,700
MF2	0	1	0	39,100	39,100
MG1	23	0	180,000	0	180,000
MG2	9	3	70,400	117,400	187,800
MH	24	0	187,800	0	187,800
MD1-1	0	0	0	0	0
MD1-2	22	0	172,200	0	172,200
Totals	1,392	31	$10,860,600	$1,212,900	$12,073,600

1/ Includes structure costs, land costs, relocation expenses, and contingencies.

2/ Does not include relocation of public facilities (i.e., roads, sewers, sidewalks, telephone lines, etc.)

TABLE B-34
ANNUAL BENEFITS AND COSTS OF RELOCATION
OF STRUCTURES IN THE 10-YEAR FLOOD PLAIN
(7-1/8%)

Item	Annual Benefits1/	Annual Costs
Residential		
Ins. Savings	$ 427,500	
Adm. Costs	20,800	
Flood Fight	138,800	
Total	$ 587,100	$ 10,860,600
Commercial		
Ins. Savings	$ 78,400	
Adm. Costs	500	
Flood Fight	141,900	
Total	$ 220,800	$ 1,212,900
TOTAL	$ 807,900	$ 12,073,500

BCR = 0.07

1/ It is recognized that these benefits are not complete but are more than sufficient to clearly demonstrate the uneconomic performance of this relocation alternative.

control channel improvement plan, sized to prevent the 10-year frequency flood, was accomplished to compare pure nonstructural versus pure structural solution alternatives.

149. The costs of this "traditional" channel improvement plan clearly outweight the benefits. Further, the environmental and aesthetic damages caused by such a highly structured concrete solution are unacceptable. The performance of the all channel 10-year plan is discussed in hydrology APPENDIX D. The cost to construct this plan is estimated to be about $148,000,000. No further consideration of channel improvements operating alone was justified. The flood control performance of the traditional 10-year plan is described in economic terms as shown below:

Annual damages before protection:	$ 4,145,000
Annual damages with 10-year plan	990,000
Net Benefits	$ 3,155,000
Average annual cost (6-7/8%)	$10,182,000
Average annual cost (7-1/8%)	10,552,000
BCR (6-7/8%)	0.31
BCR (7-1/8%)	0.30

150. It is clear at this point that the traditional 10-year plan is not economically viable and further analysis is not warranted. In addition the plan reduces annual damages by only 76 percent. Even though the pure structural plan performs considerably better than the pure nonstructural plan, neither plan is realistic in the face of the many better alternatives available.

Cycle Three "Conventional" Plan

151. In order to broaden the array of alternatives to include the full range practicable, and to review a more conventional alternative, the cycle three "conventional" plan 123 was reexamined. The computer analysis used in this cycle four examination assigned computer run 35.7 to plan 123. The composition

of this cycle three "conventional" plan and the extensive formulation process used to compose its performance is explained herein during the cycle three presentation. TABLE B-35 summarizes the features and performance of the cycle three "conventional" plan on an analysis procedure and level of detail comparable with the other fourth cycle final plan candidates. This alternative makes no use of low level flood protectors, and therefore is able to reduce the average annual flood damages by only about 70 percent. In this manner, it was recognized that low level flood protection is capable of further reducing average annual flood damages by some 22 percent.

NED Plan Rationale

152. Net economic benefits are maximized when plan scale is optimized and the plan is economically efficient. Scale is optimized when the benefits of the last increment of output for each measure in the plan equals the economic costs of that increment. A plan is economically efficient when the outputs of the plan are achieved in a least cost manner. In all cases, the design of physical structures must be done according to sound engineering criteria. As is true for all alternatives, fundamental design is based upon the interdisciplinary inputs of the planning team. Because an NED plan must address all planning objectives whose incremental dollar benefits exceed dollar costs, the planning objectives that require mitigation, preservation, or enhancement measures are also included when they are economically justified.

153. The search for a plan that maximizes net economic benefits focused on finding the optimum flood control alternative that met the previously identified screening criteria. In order to add greater certainty to the search for the optimum the NED plan, 16 plans that passed the updated formulation screening criteria were analyzed in greater detail in terms of benefits and costs. Benefits were updated and additional cost refinements were added to reflect

TABLE B-35

CYCLE THREE "CONVENTIONAL" PLAN

(7-1/8%)

Channel Reach	No Plan Damages ($1000)	Benefits ($1000)	Damages Remaining ($1000)	Measures Used 1/
M16	$ 131	$ 59	$ 72	No Action
M15	20	9	11	No Action
MH	35	15	20	Small Earth Channel
M14	70	70	0	Small Earth Channel
M13	94	88	6	Small "U" Frame Channel
M12	615	524	91	Medium Concrete Channel
MG2	530	403	127	No Action
MG1	18	0	18	No Action
MF2	6	1	5	No Action
MF1	3	1	2	No Action
M11	314	254	60	Small Concrete Channel
M10	219	184	35	Medium Earth Channel
M9	99	-2	101	No Action
M8	395	361	34	Small Earth Channel
M7	7	-1	8	No Action
M6	197	145	52	Small Earth Channel
MD6	14	3	11	No Action
MD5	47	12	35	No Action
MD4	35	18	17	No Action
MD3	51	10	41	No Action
MD1-3		0	0	No Action
MD1-2	55	32	23	No Action
MD1-1	4	2	2	No Action
MD2	136	45	91	No Action
MD1	24	10	14	No Action
M5	594	537	57	Large Earth Channel
M4	68	52	16	Small Earth Channel
MC	121	0	121	No Action
M3	67	57	10	Small Earth Channel
MB	22	0	22	No Action
M2	26	1	25	No Action
MA	89	0	89	No Action
M1	39	2	37	No Action
TOTAL	$4,145	$2,891	$1,254	No Action

1/ Plus 8 dry detentions in reaches M27, M22, MH1, MF2, MC-1, MD2-2 and MD1-1.

greater economic and engineering detail. TABLE B-36 (a and b) provides a gross summary of the screening accomplished. The complete analysis for each of the 16 plans on the basis of each of its 33 individual stream reaches and 15 potential detention sites is available for inspection and review in the Urban Studies Section, St. Louis District, Corps of Engineers. This detailed analysis includes the reach identification, annual damages without improvements, the cost of non-structural components, channel costs, bridge replacements, expected real estate purchases, easements and rights-of-way, annual benefits, and other decision items. Before drawing attention to the optimum NED plan, a discussion of the rationale leading to this selection is appropriate.

TABLE B-36A

NED SCREENING CRITERIA

6-7/8%

SCREENING CRITERIA	50.6	50.7	52.7	63.7	72.2	72.3	72.4
Annual Costs ($1000)							
Protectors	582	668	605	591	553	549	542
Channels	299	299	0	92	299	299	299
Bridges	266	266	266	235	266	266	266
Buyouts	347	337	337	316	347	347	347
Easement/Right-of-Way	57	54	54	60	55	55	5
Detention	483	483	483	483	483	483	483
Total Costs	2034	2107	1745	1777	2003	1999	1992
Other Costs[1/]	387	387	387	387	387	387	387
Total Costs	2421	2494	2132	2164	2390	2386	2379
Annual Benefits ($1000)	3355	3415	2828	2836	3372	3318	[illegible]
Net Benefits	934	921	696	672	982	932	965
Benefit to Cost Ratio	1.39	1.37	1.33	1.31	1.41	[illegible]	1.41
Percent Damage Reduction	81	82	68	68	81	80	[illegible]

SCREENING CRITERIA	72.5	72.6	72.9	74.2	74.5	74.6	[illegible]	[illegible]	78.4
Annual Costs ($1000)									
Protectors	542	542	[illegible]	733	[illegible]	733	812	812	812
Channels	299	299	299	332	[illegible]	[illegible]	544	199	[illegible]
Bridges	266	266	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Buyouts	347	347	347	[illegible]	[illegible]	347	[illegible]	[illegible]	347
Easement/Right-of-Way	55	55	55	[illegible]	72	72	[illegible]	[illegible]	79
Detention	483	483	[illegible]	[illegible]	483	[illegible]	[illegible]	[illegible]	[illegible]
Total Costs	1992	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2275
Other Costs[1/]	387	387	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Total Costs	2379	[illegible]	2386	[illegible]	[illegible]	2587	[illegible]	2563	[illegible]
Annual Benefits ($1000)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Net Benefits	[illegible]	954	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Benefit to Cost Ratio	1.41	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Percent Damage Reduction	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	92	91	[illegible]

[1/] Other costs include sewer outfalls and interior drainage system costs.

TABLE 4-38

NED SCREENING CRITERIA

7-1/8%

SCREENING CRITERIA	50.6	50.7	52.7	63.7	72.2	72.3	72.4	72.5	72.6	72.9	74.2	74.[illegible]	74.6	7[illegible]	75.3	74.4
Annual Costs ($1000)																
Protectors	602	591	626	612	572	568	561	561	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Channels	309	339	0	95	309	309	309	309	[illegible]	309	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Bridges	275	275	295	243	275	275	275	275	[illegible]	275	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Buyouts	359	349	349	327	359	359	359	359	359	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Easement/Right-of-Way	59	56	56	62	57	57	57	57	[illegible]	[illegible]	75	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Detention	500	500	500	500	500	500	500	500	[illegible]	500	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Total Costs	2104	2180	1806	1839	2072	2065	2061	2061	2061	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Other Costs[1]	400	400	400	400	400	400	400	400	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Total Costs	2504	2580	2206	2239	2472	2468	2461	2461	2461	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Annual Benefits ($1000)	3355	3463	2848	2836	3372	3374	3344	[illegible]	3333	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Net Benefits	851	883	642	597	900	906	883	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1150	[illegible]
Benefit to Cost Ratio	1.33	1.34	1.27	1.31	1.36	1.35	1.35	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Percent Damage Reduction	81	[illegible]	68	68	81	80	81	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	81	[illegible]

[1] Other costs include sewer outfalls and interior drainage system costs.

154. During the development of the alternative plans, screening actions were taken which led to a plan that maximized net benefits. The first of these actions tested the economic viability of all detention sites. TABLE B-37 summarizes the results of the detention site analysis at 6-7/8 percent interest rate. All detention sites were ranked for each of their alternative outlet sizes and flood storage capacities by order of economic performance. The details of this analysis are available for inspection in the Urban Studies Section, St. Louis District, Corps of Engineers. The final sites (at 7-1/8%) identified as providing the best economic viability are as follows:

ECONOMICALLY FEASIBLE DETENTION SITES
7-1/8%

Detention Site	Elevation	Outlet Size	Annual Cost ($1000)	Annual Benefit ($1000)	Net Benefit ($1000)	BCR
M27	570	3	$ 74	$212	$133	2.83
M22	565	3	41	72	31	1.76
MH-1	565	1	59	110	51	1.86
MF-1	560	1	77	79	2	1.03
MF-2	530	1	68	78	10	1.15
MD-1	510	5	80	73	-7	.91
MD2-2	545	3	56	58	2	1.04
MD1-1	530	3	79	80	1	1.01
			$535	$762	$227	1.42

155. Notice that only one detention site (MD-1) does not have a BCR equal to or greater than 1.00. This detention site was retained because of its impact not only on the volume of flood waters it stored, but also due to its beneficial downstream impacts on hydrograph "timing." If MD-1 were removed from the system induced

TABLE B-37
MALINE CREEK
DETENTION SITE ANALYSIS

Detention Site	Elevation	Outlet[c] Size	Annual[a] Cost ($1000)	Annual[a,b] Benefit ($1000)	Net[a] Benefit ($1000)	BCR
* M27	570	(3)[d]	$ 73	$ 212	$ 139	2.90
	580	1	96	189	93	1.97
	590	1	165	205	40	1.24
	590	5	168	206	38	1.23
* M22	565	(3)[d]	40	72	32	1.80
	575	1	55	89	34	1.62
	580	1	76	89	13	1.17
	580	5	78	69	-9	.88
* MH-1	555	3	40	63	23	1.58
	565	(1)[d]	57	110	53	1.93
	570	1	72	111	39	1.54
	570	5	74	44	-30	.59
* MF-1	540	3	38	39	1	1.03
	560	(1)[d]	75	79	4	1.05
	570	1	108	84	-24	.78
	570	5	112	55	-57	.49
* MF-2	520	3	95	17	-38	.31
	527	1	62	55	-7	.89
	530	(1)[d]	66	78	12	1.18
	530	5	68	21	-47	.31
M-13	490	3	75	52	-23	.69
	500	1	95	56	-39	.59
	510	1	155	73	-82	.47
	510	5	158	54	-104	.34
MD-1	505	3	64	12	-52	.19
	510	1	77	32	-45	.42
	510	(5)[d]	78	73	-5	.94
* MD2-2	545	(3)[d]	54	58	4	1.07
	555	1	69	64	-5	.93
	560	1	89	68	-21	.76
	560	5	93	54	-39	.58
MD-2	500	3	25	3	-22	.12
	510	1	45	21	-24	.47
	515	1	63	21	-42	.33
	515	5	65	2	-63	.03
MD1-1	530	(3)[d]	77	80	3	1.04
	540	1	99	85	-14	.85
	550	1	153	90	-63	.59
	550	5	155	74	-81	.48

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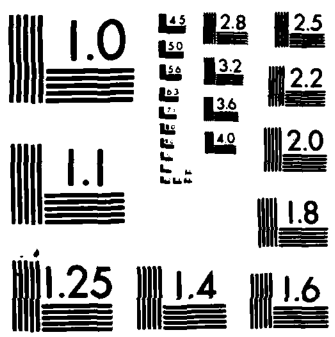

MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

TABLE B-37 (Continued)
MALINE CREEK
DETENTION SITE ANALYSIS

Detention Site	Elevation	Outlet[c] Size	Annual[a] Cost ($1000)	Annual[a,b] Benefit ($1000)	Net[a] Benefit ($1000)	BCR
MD1-2	525	3	33	18	-15	.55
	535	1	53	28	-25	.53
	545	1	89	29	-60	.33
	545	5	90	18	-72	.20
MC-1	510	3	41	9	-32	.22
	515	1	56	13	-43	.23
	520	1	72	13	-59	.18
	520	5	75	8	-67	.11
MC-2	485	3	36	23	-13	.64
	495	1	61	24	-37	.39
	505	1	113	34	-79	.30
	505	5	114	31	-83	.27
MB-1	485	3	51	8	-43	.16
	495	1	72	10	-62	.14
	505	1	121	11	-110	.09
	505	5	124	8	-116	.06
MB-2	465	3	30	2	-28	.07
	470	1	39	9	-30	.23
	480	1	59	9	-50	.15
	480	5	60	3	-57	.05

[a]All figures are in thousands of dollars. Interest rate = 6-7/8% (.06875).
[b]Benefits computed on a first-added basis.
[c]Low level outlets of diameters 2, 3, 4, 4.5, 5, 5.5, 6, 7 and 8 feet correspond to outlet size numbers 1-9 respectively.
[d]Detention sites chosen as most useful.
*Has at least one dam/outlet configuration that is justified.

damages would result. In other words, each detention site was initially tested incrementally - acting on its own - without other detentions, channel improvements, bridge removals, or non-structural measures. Based on this "independent" approach all but one of the sites (MD-1) added net benefits. Acting as part of a system, MD-1 becomes economically justified because removal of MD-1 from the remaining sixteen system plans would cause induced damages. The system of eight detentions has a BCR of 1.42 with $227,000 of net benefits. The addition of any other site would add more to annual costs than to annual benefits and the removal of any of these eight sites would detract from benefits to a greater extent than from costs.

156. Once having resolved the economics of detention sites, a search for channel and non-structural improvements took place. The thrust of this search initially centered on finding the least costly alternatives. An exhaustive analysis proved that detentions and a wide mix of channel improvements resulted in plans with BCR's less than 1.00 or did not satisfy stated goals, objectives, and constraints. Additional details regarding the poor benefit to cost performance of all sizes of channel improvements is presented in APPENDIX H - ECONOMICS. In summary, none of the channel improvement methods suitable for Maline Creek performed well at medium or large sizes. Concrete "U-frame," gabion, concrete trapezoidal and earth trapezoidal were the channel improvement techniques thoroughly tested. The analysis presented in the economics appendix indicates that 18 of the 33 stream reaches were unable to economically support any channel improvements, and five of the 33 could only support very limited improvements.

157. An examination of the concepts behind nonstructural solutions led to consideration of more recent flood protection concepts - one is called a low level flood protection. Previous ideas about

nonstructural solutions included constructing small berms around individual homes located in flood prone areas. This concept was expanded to include low level berms around larger aggregates of homes - say 50 or 100 at one time. The low level flood protector is a 2 or 3-foot continuous ring berm circumscribing a number of homes and tying to high ground at each end. A low level flood protector would not in-and-of itself stop all flood damages but was used in combination with detention and channel improvements to provide increased economically justified flood protection. The details of the economic viability of low level flood protectors is presented in APPENDIX H - ECONOMICS. An extensive comparison of low level protectors versus other methods indicates they are far less costly than most channel modifications and would serve to either replace or reduce the size of channel improvements in many reaches. The detentions and channel modifications did most of the work in lowering flood profiles and the low level flood protectors prevent the frequent and nuisance type low level flood occurrences. The low level flood protector technique was developed in recognition that much of the damages in the Maline Creek flood plain are caused by frequent relatively low level flood events of basically an inconvenience rather than catastrophy nature. Prevention of these low level inconvenience flood events provides a much needed community service. The low level flood protection is very well suited to preventing nuisance type flood damages. The low level flood protection is used to control the flood waters and is therefore categorized as a "structural" management measure even though strongly resembling "nonstructural" flood proofing techniques.

158. The results of using detentions, channel improvements, low level flood protectors, and bridge replacements are illustrated in TABLE B-36. These plans are further summarized below:

SUMMARY OF
NED CANDIDATES
COSTS AND BENEFITS (7-1/8%)

Plan	Annual Benefits ($1,000)	Annual Costs ($1,000)	Net Benefits ($1,000)	BCR
50.6	$3,355	$2,505	$ 850	1.34
50.7	3,463	2,581	882	1.34
52.7	2,848	2,206	642	1.29
63.7	2,836	2,239	600	1.27
72.2	3,372	2,473	899	1.36
72.3	3,334	2,469	865	1.35
72.4	3,344	2,462	882	1.36
72.5	3,324	2,462	862	1.35
72.6	3,333	2,462	871	1.35
72.9	3,346	2,469	877	1.36
74.2	3,709	2,711	989	1.36
74.5	3,671	2,945	729	1.25
74.6	3,649	2,677	972	1.36
78.2	3,841	3,122	719	1.23
78.3	3,822	2,673	1,149	1.43
78.4	3,775	2,775	1,020	1.37

159. The data indicates that plan 78.3 maximizes net economic flood control benefits. It is therefore designated as the flood control NED plan. The selection of plan 78.3 as the flood control NED plan was confirmed by a plot of optimization points and resulting curve analysis as described in APPENDIX H - ECONOMICS. Plan 78.3 optimizes the flood control benefits. Next pursued was a plan that optimizes all benefits (i.e., flood control plus recreation).

Optimum NED Plan

160. The search for a plan which minimizes (the do-nothing alternative not withstanding) net economic benefits thus far focused on flood control. This was done to confirm that flood control can stand on its own in terms of benefits and costs. A true optimal plan must include all benefits and all costs. The following

paragraphs intend to complete the analysis and identify the final optimum plan. Recreation benefits were optimized along with flood control to achieve the optimum NED plan.

161. Recreation Benefits. In addition to flood control benefits and costs, the final sixteen NED candidates contained recreation and associated environmental benefits and costs. The following basic information was used to evaluate recreation and environmental benefits.

a. The activity day-use and benefit values were evaluated for load applicablilty. Outdoor recreation activity was uniformly valued at $1.75 per visitor-day. The lengths of flood plain trails included 5.49 miles in reaches M6 to M16, 0.41 miles in tributary MB, 0.47 miles in tributary MD1, and 0.43 miles in tributary MH1. The flood plain trail activities were based on 9,000 biking visitations per mile of trail (annually) and 7,040 hiking visitations per mile of trail (annually).

b. An investigation into the flood control components of each of the final NED candidates indicates modest variability in terms of channel sizes, low level protectors, and bridge removals. These variations did not affect either the recreation or environmental benefits and costs. In other words, the overall recreation scheme was largely unaffected by the variations in and among the alternatives. The benefits and costs are the same. The same detentions, trails, fisheries, picnicking, etc., are apparent to all sixteen candidates.

c. TABLE B-38 illustrates the details of the recreation-environmental benefit analysis. This information will be refined upon addressing the details of the recommended plan.

162. Redevelopment Benefits. There are no redevelopment benefits applicable to the Maline Creek study area.

163. Optimum NED Plan. TABLE B-39 provides information on all benefits and costs for each NED candidate. Once again, a graphical plot and analysis of these data shows that with the added recreation-environmental data plan 78.3 produced the highest net benefits and was thus confirmed as the optimum NED plan. The data for the nonstructural 100-year flood plain relocation plan are also shown in TABLE B-39.

EQ Plan Rationale

164. The EQ plan must satisfy all formulation screening criteria (just as did the NED plan), only the primary emphasis was EQ performance. Therefore, the 16 plans passing the updated formulated screening were reviewed for selection of the flood control features of the EQ plan. Plan 78.2 was adopted as the base upon which to create the EQ plan. Carried through the entire formulation process was a nonstructural alternative, the "traditional" plan and the cycle three draft "conventional" plan in order to display the comprehensive diversity of alternatives considered. These three additional alternatives were found to perform poorly when compared to the other available alternatives.

165. Environmental Quality and Recreation features developed during previous iterations were then reviewed for inclusion in the EQ plan. The EQ and recreation features included in the EQ plan consist of aquatic habitat structures to create instream pools, fish ponds, open space land acquisition, outdoor recreation development, and litter/debris control. Each of these components is discussed in the following paragraphs.

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b. An investigation into the flood control components of each of the final NED candidates indicates modest variability in terms of channel sizes, low level protectors, and bridge removals. These variations did not affect either the recreation or environmental benefits and costs. In other words, the overall recreation scheme was largely unaffected by the variations in and among the alternatives. The benefits and costs are the same. The same detentions, trails, fisheries, picnicking, etc., are apparent to all sixteen candidates.

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TABLE B-38
MALINE CREEK
ESTIMATED EQ-REC TANGIBLE BENEFITS ($1000)
ACTIVITY

ITEM	FISHERIES	GROUP CAMPING	BICYCLING	NATURE WALKS	GAME FIELDS	PICNICKING	TOTAL ANNUAL BENEFITS
A. DETENTION SITES							
M27	$ 0*	$ 0	$ 24	$ 18	$ 42	$ 59	$ 143
M22	0*	0	24	18	32	22	96
MH1	0*	0	21	16	53	62	152
MF1	0	0	0	6	0	29	35
MF2	0	0	6	4	21	29	60
MD1	0	0	4	3	21	29	57
MD2-2	0*	5	0	19	0	59	83
MD1-1	0*	0	16	12	32	59	119
SUBTOTAL	$ 0	$ 5	$ 95	$ 96	$ 201	$ 348	$ 745
B. FLOOD PLAIN TRAIL							
M6 to M-16	$ 1	$ 0	$ 86	$ 68	$ 0	$ 0	$ 155
MB	0	0	6	5	0	0	11
MD1	1	0	7	6	0	0	14
MH1	0	0	7	5	0	0	12
SUBTOTAL	$ 2	$ 0	$ 106	$ 84	$ 0	$ 0	$ 192
C. RAILROAD RIGHT-OF-WAY	$ 0	$ 0	$ 0	$ 0	$ 0	$ 0	$ 0
D. TOTAL AVERAGE ANNUAL BENEFITS	$ 2	$ 5	$ 201	$ 180	$ 201	$ 348	$ 937

*Less than $500 average annual benefits.

TABLE B-39
NED PLAN FORMULATION
TOTAL AVERAGE ANNUAL BENEFITS AND COSTS: 7-1/8%
($1000)

Plan	Flood Control Benefits	Rec/EQ Benefits	Total Benefits	Flood Control Costs	Rec/EQ Costs	Total Costs	BCR	Net Benefits
50.6	$3,355	$ 937	$4,292	$2,505	$ 470	$2,975	1.44	$1,317
50.7	3,463	937	4,400	2,581	470	3,051	1.44	1,349
52.7	2,848	937	3,785	2,206	470	2,676	1.41	1,109
63.7	2,836	937	3,773	2,239	470	2,709	1.39	1,064
72.2	3,372	937	4,309	2,473	470	2,943	1.46	1,366
72.3	3,334	937	4,271	2,469	470	2,939	1.45	1,332
72.4	3,344	937	4,281	2,462	470	2,932	1.46	1,349
72.5	3,324	937	4,261	2,462	470	2,932	1.45	1,329
72.6	3,333	937	4,270	2,462	470	2,932	1.46	1,338
72.9	3,346	937	4,283	2,469	470	2,939	1.46	1,344
74.2	3,700	937	4,637	2,711	470	3,181	1.46	1,456
74.5	3,674	937	4,611	2,945	470	3,415	1.35	1,196
74.6	3,649	937	4,586	2,677	470	2,147	1.46	1,439
78.2	3,841	937	4,778	3,122	470	3,592	1.33	1,186
78.3	3,822	937	4,759	2,673	470	3,143	1.51	1,616
78.4	3,775	937	4,712	2,755	470	3,225	1.46	1,487
NS(1)	3,980	937	5,917	21,929	470	22,320	0.22	-17,403

(1) NS is the nonstructural 100-year flood plain relocation plan carried throughout the analysis.

a. Aquatic Habitat Structures. Aquatic habitat diversity would be enhanced by constructing 18 aquatic habitat structures at approximately 0.5 mile intervals throughout stream reaches M1 through M14 and MD1. Flood control plan 78.2 provides for grade control structures in these same locations. The design was modified to serve the dual purposes of providing pools for fish and other aquatic biota while retaining the grade control function. The design details of these structures are shown in PLATE E-57.

b. Fish Ponds. Aquatic habitat diversity would be further enhanced by constructing fish ponds immediately downstream from detention basins MD1-1, MD2-2, MH1, M22, and M27. The ponds would vary in size from 2 to 4 acres, and would be appropriately stocked to provide fishing opportunities at these sites. A total of 14 surface acres would be provided by these ponds. A typical perspective of these structures is shown in PLATE E-66.

c. Open Space Land Acquisition. Two hundred seventy-seven acres of undeveloped land would be acquired to address terrestrial wildlife habitat and outdoor recreation needs. Of these 277 acres, 252 would be in addition and adjacent to the real estate required for flood control detention basins. Four acres would be acquired to preserve a small bottomland hardwood forest in stream reach MD1-1. Five acres would be acquired to extend a trail system upstream from the flood control improvement area on tributary MH to detention site MH1. Sixteen acres would be acquired to extend a trail upstream of reach MB, then expand and connect Tanglewood and Wilderness parks at site MB2.

d. Outdoor Recreation Development. Opportunities for outdoor recreation would be provided through the development of the open space acquisition areas described above, in addition to the fish pools (created by aquatic habitat structures) and fish ponds. The specific activity opportunities at each of the above are described in APPENDIX F.

e. Litter/Debris Control. An extensive litter/debris clean-up would be included to improve the aesthetic appearance of the project area. On-going clean-up would be required of local interests to maintain the enhanced visual impact of the project.

166. One feature that had been developed during previous iterations - stream bank stabilization - was dropped as an EQ/Recreation feature. Erosion areas in stream reaches M2 and M8 have been locally repaired since the inventory was completed, further proving the dynamics of change in urban areas. Erosion areas in stream reaches M5, M10 and M12 are located in reaches planned for eventual channelization; hence, no stabilization would be required. Erosion areas in reaches M2 and M4 are adjacent to areas where low level flood protectors are planned, which will stabilize the banks to avoid erosion damage to those flood control improvements. Erosion areas in stream reaches M4, M7, M9, MD1 and MD2 are remote from residential and business structures. Therefore, stream bank erosion stabilization was considered unnecessary in those stream reaches.

167. Summary EQ Candidate. The EQ plan is plan 78.2 with the addition of aquatic habitat structures, fish ponds and other features as described herein.

Recommended Plan Rationale

168. Selection of a recommended plan of improvements was based on use of Social Well-Being, Regional Development, Environmental Quality and Flood Control planning as decision criteria.

169. Social Well-Being Impact Analysis. TABLE B-29, discussed earlier, presents the data used for social well-being screening. During the elimination process six of the fourteen variables were found to be useful in discriminating between positive and adverse alternatives. The following variables were not used because they showed little or no variation:

Screening Variables Eliminated

Variable	Reason for Eliminating
(1) Noise levels	Small variance
(2) Aestehtic values	No judgments made
(3) Archaeological sites	No sites
(4) Historic sites	No sites
(5) Transportation	No basis
(6) Education	No impact
(7) Cultural Values	No impact
(8) Institution	No impact

The variables which were useful for making screening decisions are as follows:

(1) Homes displaced
(2) Housing values
(3) Leisure
(4) Cohesion
(5) Regional growth
(6) Health, safety, and welfare

a. Homes Displaced. As described earlier in the report, each alternative was evaluated in terms of the number of homes that would be displaced (purchased in fee simple) to prevent flood damages and for construction purposes. Displacement is both economically and socially injurious. It is economically injurious because a person or family suffers losses above and beyond those compensable under the Uniform Relocation Assistance and Real Property Acquisition Policy Act of 1970; it is socially injurious when it involves dispersion and break up of cultural units and neighborhoods. In order to minimize this adverse impact all plans which would displace 150 or more units were eliminated. It was felt that the purchase and resettlement of more than this number of units was overly adverse. Most of the remaining plans would still require the resettlement of housing units, but the number of units was less socially adverse.

b. Housing Values. The principles for rating housing values was discussed earlier in the report. All plans which made housing quality worse off were eliminated. Part of the purpose of flood control projects is to improve housing quality through flood damage reduction. Plans which fail to do this are not viable.

c. Leisure Opportunity. The need for recreation resources on the study area is substantial. The deficiences in park acreage by year is presented below:

Maline Creek
Acreage Deficiences by Year

Year	Total Acreage
1970	515
1980	672
1990	834
2000	884
2010	928
2020	943

Most of the alternative plans studied would contribute to easing the park deficiency problems though the development of dry detentions. The greatest shortages are in neighborhood and district parks which account for an average of 75 percent in expected deficiencies over time. Any plan which utilizes at lease seven detention sites would relieve these deficiences by the addition of 227 acres. To screen alternatives, any plan which did not use at least seven detention sites was eliminated. Some flood control plans used no detention and a few used fifteen detentions. The average number was eight. The remaining plan would contribute to the elimination of park acreage deficiencies, relieve park carrying capacity problems, and increase recreation opportunity.

d. Community Cohesion. As discussed earlier, community cohesion was based upon the degree of flood damage reduction. Plans which did not reduce annual flood damages by at least 75 percent were eliminated. This percentage is arbitrary but damage reduction of lesser degrees might lose community interest in flood control.

e. Regional Growth. Alternatives which demonstrated a low growth potential were screened out. An alternative which was moderate to high growth inclined is needed to aid in reducing unemployment and underemployment problems.

f. Health, Safety, and Welfare. This parameter was quantified by the percent damage remaining after a 100-year frequency event. It was felt that any plan which did not eliminate at least 50 percent of the damages of this event was unsatisfactory. This constraint is somewhat arbitrary but served to eliminate those plans which did not substantially contribute to the improvement of community health, safety and welfare. A 50 percent reduction of 100-year event damages makes substantial contributions in reducing catastrophic losses.

170. In total, the screening process above aided in eliminating plans which performed poorly from a social well-being perspective. Some plans failed each and every constraint and criteria listed above. Most plans failed in at least three of the constraints. Only 21 percent of the alternative plans passed the constraints screening. The plan eventually recommended, the EQ plan, and the NED plan passed all social well-being constraints and are therefore considered socially desirable.

171. Regional Development Screening. TABLE B-30 illustrates the variables used in Regional Development screening. Only one of the variables - Displaced Farms - was not useful in screening. All other variables showed enough variability to be used for screening.

a. Tax Revenue. Most local and regional governments throughout the nation are experiencing a fiscal crisis due to voter rebellion on tax increases. Social services and facilities are still required and must be paid for. This crisis is severe enough

that any solution proposed for Maline Creek should contribute to the maximum in assisting local governments in their abilities to raise revenue. The maximum tax revenue that is generated by any of the alternative plans is $770,000. Any plan which does not contribute at least this amount of tax revenue was screened out.

b. Property Values. It is known that the difference in value of homes located on the flood plain and those off the flood plain in Maline Creek is $1,800. The maximum contribution made by any of the alternative plans to the capturing of this difference was $1,500. Plans which did not capture at least this amount were eliminated.

c. Public Facilities/Public Services. The measure of public facilities and services was the number of dry detentions proposed by each plan. With each detention site there is also trails, parks, nature walks, and bicycling - each is a facility and has an associated service. As discussed earlier, these facilities and services have a recreation and flood control component and at least seven dry detentions are needed to relieve the park acreage deficiencies. Alternatives contributing less than seven detention sites did not contribute enough to easing public facilities/service problems and shortages were eliminated.

d. Man-Years of Employment. The unemployment rate for the St. Louis Standard Metropolitan Statistical Area (SMSA) is 5.2 percent. Plans contributing the most to eliminating this problem were retained. The greatest contributions were made by contributing 1,533 man-years of work. All other plans were screened out.

e. Business Activities. Business growth and sales activity are important to the welfare of any urban area. It is tied to state and local taxes, employment, and personal income. With the multiplier effects, the best plans created sales of $77,200,000. Alternatives generating less sales activity were screened out.

172. As before, the screening criterial established during this analysis eliminated plans not contributing to Regional Development or were weak in positive contributions. Fifty-five percent of the alternatives remainined - forty-five percent performed poorly. The plan eventually recommended, the EQ plan and the NED plan passed all criteria.

173. Environmental Quality Screening. TABLE B-31 provides the data used for environmental screening. Since there are no endangered or theatened species in the Maline Creek basin, this variable did not contribute to the screening process. A nonstructural plan was carried through the entire planning process even though it failed a number of the environmental quality screening criteria.

a. Man-Made Resources. The criteria used to screen public facilities, and public services, was also used to evaluate man-made resources. The principal thrust was recreation and flood control. Plans not leading to the development of at least seven dry detention sites were not contributing enough to the development of man-made resources and were eliminated. Seven detentions were the minimum required to meet needs.

b. Natural Resources. The national energy crisis prompted the screening out of all high energy use plans. Alternatives consuming moderate-to-low energy resource inputs during construction were retained. This also aided in eliminating plans which consumed large quantities of other natural resources.

c. Air Pollution. Because of national policies such as the Clean Air Act alternatives promoting high air pollution (HAP) were dropped. These are also the same plans which use greater quantities of energy and other natural resource inputs.

d. Water Pollution. Public Law 92-500 establishes the policy, goals, and objectives of national importance to water use. As shown on TABLE B-31, each plan was evaluated in terms of its contribution to meeting the mandates of PL 92-500. The maximum number of improved reaches of any alternative was 40. Alternatives not capturing at least 75 percent of these reaches was screened out. The 75 percent figure is arbitrary but eliminating plans not contributing significantly to PL 92-500.

e. Land Pollution. As discussed earlier in the report, some plans utilized large walls and levees which were thought to contribute to significant man-made land pollution. Plan marked with a number 3 used large walls and levees and were eliminated.

f. Animal and Plant. The numbers used to evaluate a plan's impact on animal and plant habitat indicate the degree of high-grade habitat destroys by construction activities. A plan ranking 39 completely destroying all high-grade habitat. A plan showing a zero indicates complete preservation of high grade habitat. High values up to 39 are poorer alternatives and the lower values up to 10 are environmentally desirable. If a plan ranked greater than ten on this scale, it was eliminated. The value is somewhat arbitrary but preserves 75 percent of all habitat.

g. Ecosystems. Ecosystem rankings are a combined assessment of water pollution and animal and plant destruction. The values seen on TABLE B-31 are indices described earlier. The higher this number is up to a maximum of 71 (the best of all plans ecologically) the greater will be preservation. Zero represents a totally destructive alternative. If a plan did not receive a ranking of at least 53 out of 71, it was screened out. This represents 75 percent of the maximum preservation.

174. The total impact of this screening process was severe. Only 7 percent of all plans passed this criteria. The plan eventually recommended, the EQ plan and the NED were among the remaining alternatives.

Recommended Plan

175. Examining all screening criteria and all plans, only two plans passed all tests. Plans 78.2 and 78.3 meet all screening criteria as shown on TABLE B-40. Data regarding the nonstructural 100-year flood plain relocation plan are also shown in TABLE B-40. Data relative to the cycle three draft "conventional" plan (number 35.7) are also displayed in TABLE B-40. The "traditional" plan is not displayed because of its significant social and environmental hinderances. Data presented in the referenced tables reflects the screening accomplished for the final iteration of planning, 7-1/8% interest and Oct 79 price levels. Thus, the values are updated from earlier iteration information presented herein.

TABLE B-40
FINAL DECISION CRITERIA

	Plans Passing F.C. Screening			Plans Passing			Plans
Plan	Min 10-Yr. Protection	Min. 1.20 BCR	$1000 or Less Induced Dem.	SWB Screening	RD Screening	EQ Screening	Passing All Criteria
50.6	Yes	Yes	Yes	Yes	Yes	No	-
50.7	Yes	Yes	Yes	No	Yes	No	-
52.7	Yes	Yes	Yes	No	No	No	-
68.7	Yes	Yes	Yes	No	No	No	-
72.2	Yes	Yes	Yes	No	No	No	-
72.3	Yes	Yes	Yes	No	No	No	-
72.4	Yes	Yes	Yes	No	No	No	-
72.5	Yes	Yes	Yes	No	No	No	-
72.6	Yes	Yes	Yes	No	No	No	-
72.9	Yes	Yes	Yes	No	No	No	-
74.2	Yes	Yes	Yes	No	No	Yes	-
74.5	Yes	Yes	Yes	No	No	Yes	-
74.6	Yes	Yes	Yes	No	No	Yes	-
78.2	Yes	Yes	Yes	Yes	Yes	Yes	78.2
78.3	Yes	Yes	Yes	Yes	Yes	Yes	78.3
78.4	Yes	Yes	Yes	No	Yes	Yes	-
NS(1)	Yes	No	Yes	No	Yes	Yes	-
35.7(2)	No	Yes	Yes	No	Yes	No	-

(1) NS is the nonstructural 100-year flood plain relocation plan carried throughout the analysis.
(2) Performance of the cycle three draft "conventional" plan is shown as a means to displaying the widest possible diversity in alternative potential solutions. This alternative does not use low level flood protection.

B-165

176. TABLE B-41 provides a summary comparison of the performance of the final array of recommended plan candidates. The EQ plan is the recommended plan (i.e., plan 78.2).

TABLE B-41
COMPARISON OF FINAL ARRAY OF FORMULATION ALTERNATIVES
7-1/8% OCT 79 PRICE LEVELS ($1,000)

Category	EQ/Recommended Plan (78.2)	NED Plan (78.3)	Cycle Three "Conventional"
Flood Control Benefits	$3,753.0	$3,704.0	$2,891.0
Recreation/EQ Benefit	1,059.0	1,059.0	1,059.0
Total Benefits	4,812.0	4,763.0	3,950.0
Flood Control Costs	2,692.6	2,583.0	2,180.5
Recreation/EQ Costs	432.2	332.4	642.0
O&M Costs	450.0	408.2	341.0
Total Costs	3,573.8	3,323.6	3,163.5
Net Benefits	1,238.2	1,439.4	787.5
Percent Damage Red.	90%	90%	70%
Induced Damages	1.0	1.0	1.0
BCR	1.35	1.43	1.25

177. The reason flood control component 78.2 was selected over 78.3 is illustrated in TABLE B-42. TABLE B-42, part A, shows the differences in damages remaining at each flood event for the entire basin. Plan 78.2 carries with it less risk at greater flood event than does plan 78.3. TABLE B-42, part B, shows the same data but for modified reaches only. It is clear from a risk analysis that plan 78.2 provides greater flood damage reductions (even though 78.3 maximizes net tangible benefits) - especially with larger floods for the entire basin and modified reaches.

TABLE B-42

EVENT ZONAL DAMAGES REMAINING ($1000)

Plan	2-Yr.	5-Yr.	10-Yr.	25-Yr.	50-Yr.	100-Yr.	SPF
			A. Entire Basin				
78.2	$12	$53	$134	$1,401	$4,803	$ 9,988	$33,149
78.3	12	53	134	1,615	5,440	10,505	33,794
Diff.	$ 0	$ 0	$ 0	$- 214	$- 637	$- 517	$- 645
			B. Modified Reach				
78.2	$ 0	$ 0	$ 0	$1,106	$4,377	$ 8,682	$30,232
78.3	0	0	0	1,319	5,013	9,199	30,878
Diff.	$ 0	$ 0	$ 0	$- 213	$- 636	$- 517	$- 646

178. In addition to reduced flood risks at greater flood magnitudes, the EQ plan (78.2) contains fish ponds and aquatic habitat structures not in the NED plan (78.3) because they could not be incrementally justified. Thus, the EQ plan was selected based on the following trade-offs.

(1) The EQ plan has less risk during severe floods than most other plans.

(2) The EQ plan includes fish ponds that could not be included in other plans due to a lack of incremental justification.

(3) The EQ plan includes aquatic habitat structures not included in other plans, again due to a lack of incremental justification.

Structural and Nonstructural Aspects of the Recommended Plan

179. The low level flood protectors concept used for the recommended plan of improvements is a structural solution. It is the purpose of this section of the report to discuss the nature and characteristics of structural and nonstructural solutions and how the recommended plan fits into the realm of nonstructural alternatives.

180. A Hydrologic Engineering Center/Institute for Water Resources (HEC/IWR) study entitled, "Physical and Economic Feasibility of Nonstructural Flood Plain Management Measures," lists the following as nonstructural solutions:

a. Installation of temporary or permanent closures for openings in structures.

b. Raising existing structures in-place.

c. Constructing new structures on fill or columns.

d. Constructing small walls or levees around structures.

e. Relocating or protecting damageable property within an existing structure.

f. Relocating existing structures and/or contents out of a flood hazard area.

g. Use of water resistant materials in new or existing structures.

h. Regulation of development of flood plain land by zoning ordinances, subdivision regulations and building codes.

i. Acquisition of title or easement to flood plain land.

j. Flood insurance.

k. Installation of flood forecast and warning systems with an appropriate evacuation plan.

l. Adoption of tax incentives to encourage wise use of flood plain land.

m. Placement of warning signs in the flood plain to discourage development.

n. Adoption of development policies for facilities in or near flood plain land.

While this list may not include all nonstructural measures, it includes most of them.

181. The recommended plan exhibits characteristics which are typically nonstructural. Specifically, these characteristics include:

a. Acquisition of the title to flood plain land
b. Relocations

182. The recommended plan also includes the following structural components:

a. Eight Dry Detention areas.

b. Six earth channel improvements (in thirteen reaches).

c. Small berms - low level flood protectors, consisting of 5.05 miles of low flood walls plus 3.31 miles of low level levees.

d. An interior drainage network.

e. Clearing and snagging on almost 77 acres.

f. Bridge modifications consisting of 5 bridge replacements plus 2 bridge opening enlargements.

183. The recommended plan (EQ) plan improvements are generally reflective of two of the nonstructural measures identified in the HEC/IWR report. Most nonstructural measures are actions taken to individual structures or to land in or around a community. Typically structures are protected by keeping floodwater out, by constructing a small wall or levee, moving the structure from the flood plain, purchasing flood prone land, or some combination of these measures.

184. Structural solutions such as reservoirs, large levees, large floodwalls, and channel modifications protect property without regard for the selective individual nature of nonstructural approaches. They deal principally with the flood - not with the structures being protected. For example, the recommended plan for Maline Creek used select acquisition and relocations.

185. Another distinguishing quality of nonstructural measures lies in their resource saving character. Structural solutions often use large amounts of input factors during construction. Massive amounts of concrete, excavations, steel, and energy are typical. Nonstructural alternatives generally employ less resource inputs.

186. In summary, nonstructural measures are distinguished from structural measures by two factors: 1) their selective, flexible, and individual nature in providing protection, and 2) their resource saving input requirements.

187. Previous portions of this report discussed and defined the main differences between structural and nonstructural measures. The recommended plan for Maline Creek incorporates a combination of these measures as listed earlier. To facilitate understanding each nonstructural component of the Maline Creek plan they are discussed in additional detail in the following subparagraphs. The purpose in doing this is to demonstrate the structural and nonstructural character of the plan and to provide the rationale for each component.

188. Low level flood protection such as small berms are not constrained by the type or size structure it is protecting. Low level protection offers considerable flexibility in design to make them compatible with site and use. Low level protector height can vary, land form can be followed, length can be site specific, and design made aesthetically pleasing. The design used for Maline Creek took advantage of these qualities. Channel improvements were also effective in some flood control reaches and did aid in reducing flood damages but did not possess all the qualities of the low level protection. Channel improvements were far more expensive (as discussed in the NED plan formulation) and were less useful in controlling damages in specific low lying areas. Rather than place low level protection around each individual home, advantage was taken of the fact that in densely populated residential areas, homes tend to cluster. Low level protection was placed around these clusters tying to high ground. This was cost saving. Along with detentions, channel work, and bridge removals, low level protectors played a substantial role in reducing annual damages by 90 percent.

frequent nuisance type flooding was substantially reduced via low level protection providing a significant public service.

Low level protection was used to protect site specific problem areas where a channel was impractical. For example, a stretch of homes extending 400 feet along the creek were protected by a low level protector rather than a large channel improvement extending the same length. In another reach, only one side of the creek needed protection accommodated nicely by low level protectors on only one creek bank. A channel improvement would have been inefficient. Low level protectors were efficient in protecting only one side of the flood plain where the other side was not susceptible to damage.

189. Public Acquisition of Flood Plain Land. One nonstructural feature of the recommended plan is the purchase of full fee title to flood plain land. In reaches receiving protection from channel modifications, the land was purchased for three purposes: 1) to prevent development, 2) for recreation uses, and 3) environmental preservation. Fee acquisition conveys ownership from private to public lands allowing public uses compatible with flood hazards. In this case the lands will be used for open space, parks, and environmental corridors. Fee purchase is most appropriate for undeveloped land or land with few structures in place. This particular nonstructural measure served a multi-purpose function providing spin-off advantages including: 1) the prevention of damages to present and future urbanization, 2) recreation such as trails, picnicking, fishing, and environmental education, 3) environmental preservation of select high quality sites, 4) compatibility with local park development, 5) in-stream flood control storage, and 6) compatibility with local sponsor intentions. Fee purchase also meets nonstructural requirement - it

is a localized, selective action and requires little resource inputs. For Maline Creek land purchase came to 858 acres for all purposes.

190. Detentions. Related to land acquisition but being a structural component in-and-of itself is the use of dry detention for flood control purposes. Another need which can be met by fee purchase is flood plain storage. Loss of channel capacity by increased urbanization can cause increases in flood stages and higher peak flows downstream. Acquisition can be used to maintain this storage and simultaneously control future development and provide for wise flood plain use such as recreation, open space, or wildlife preservation. In the case of Maline Creek, areas of storage will be used for recreation and open space while providing storage capacity. The dry detention sites chosen include the following:

Site	Drainage Area (Acres)	Maximum Pool Area (Acres)	Max. Storage (Acre/Feet)
M27	525	63	942
M22	101	16	215
MH1	123	20	277
MF1	300	30	514
MF2	220	6	56
MD1	422	10	52
MD2-2	198	30	407
MD1-1	422	52	786

191. Dry detention sites also meet recreation needs by providing additional open space and relieving the existing and expected future recreational and park land shortages. The carrying capacity of existing recreation areas in the Maline Creek basin is already under stress as witnessed by crowded conditions.

192. Bridge Modifications. There are five bridge replacements and two bridge improvements associated with the recommended plan. During the formulation of the 374 alternatives it was recognized that bridge modifications did not always aid in preventing damages. Some bridges modified hydrograph timing and aided in preventing damages downstream. Other bridge modifications increased flood damages. Those bridge changes which reduced damages were adopted. Bridges are not "new" to the flood problem. Old bridges were not problems until urbanization increased runoff. Flood flows became problems because of urbanization - not because of bridges. Urbanization of lands outside the flood plain area are the primary cause of the increased rainfall runoff that causes increased flooding. Non-flood plain residents cause more sewer increased runoff problems than do flood plain residents simply due to their much greater population.

193. Clearing/Snagging/Brush Hogging. These measures are traditionally structural. They involve changes in "friction" to flood flows. The recommended plan incorporates 73 areas of these measures. They are selective and comparatively non-resource conservative. Their character is utilized in reducing the "Manning coefficient" changing flood volume, backwater, and hydrograph timing. They also fit the definition of structural measures.

Recommended Plan Without Low Level Flood Protectors

194. The performance of the recommended plan of improvements without use of low level flood protectors was studied. It can be observed that this test clearly proves that low level flood protectors are a very effective flood control management measure preventing damages from 10-year or lesser flood event. This test provides proof positive that low level flood protectors are viable and necessary features for an effective and efficient recommended plan of improvements.

195. The hydraulic performance of the recommended plan without low level flood protectors is shown in plates explained in the hydrology discussions APPENDIX D. With respect to the economic analysis, TABLE B-42A demonstrates the beneficial impacts of the low level flood protectors. The realistic plan without the flood protectors is the "conventional" plan which includes: channel improvements, detentions, sewer modifications, and all other flood control design features. The modified recommended plan has a good BCR but is only 70 percent effective in reducing annual flood damages. Remaining annual damages amount to $1,254,000 as compared to the recommended plan's $392,000 and 90 percent effectiveness. As TABLE B-43 indicates, the flood protectors contribute 30 percent to benefits between channels and protectors and 17 percent to toal plan benefits. Remaining damage increased by nearly fourfold without the flood protectors. The recommended plan with the flood protectors appears more effective. A single exclusion of levees from the recommended plan yields an impractical solution, thus basic reformulation would be required as represented by the "conventional" plan.

TABLE B-42A
MALINE CREEK
RECOMMENDED PLAN WITHOUT FLOOD PROTECTORS PLAN COMPARISON
7-1/8% OCT 79 PRICE LEVELS

Plan	F.C. 1/ Annual Benefits	F.C. 1/ Annual Costs	Remaining Damages	% Dmg. Reduc.	F.C. BCR
Recommended Plan	$3,753,000	$2,997,200	$ 392,000	90%	1.25
Less Protectors "Conventional"	2,891,000	2,179,500	1,254,000	70%	1.33
Difference	862,000	817,700	3,283,000	20%	1.05

1/ Average annual damages without protection $4,145,000.
2/ Includes appropriate O&M costs.

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TABLE B-43

MALINE CREEK

EFFECT OF FLOOD PROTECTORS (7 1/8%)

Reach With Flood Protector	Benefits from Flood Protectors Only	Benefits from Channels	Total Benefits
M15	4,000	15,000	19,000
MH	5,600	25,400	31,000
M14	32,800	31,200	64,000
M13	32,600	53,400	86,000
M12	224,000	342,000	566,000
M10	30,200	160,800	191,000
M9	38,900	44,100	83,000
M7	600	2,400	3,000
M6	49,200	133,800	183,000
MD5	7,400	29,600	37,000
MD3	15,900	29,100	45,000
MD1-2	13,000	27,000	40,000
MD2	49,100	72,900	122,000
M5	108,300	463,700	572,000
M4	5,800	50,200	56,000
M3	24,000	36,000	60,000
M2	7,400	14,600	22,000
M1	3,600	24,400	28,000
	$652,400	$1,555,600	$2,208,000
% Benefits	30%	70%	100%

Benefits from flood protectors	$ 652,400
Benefits from channels	1,555,600
Benefits from bridges and other reaches	1,545,000
TOTAL	$3,753,000

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Impact Assessment

196. The environmental effects of the recommended plan, NED and EQ plans and cycle three "conventional" plan are displayed by comparing each plan's anticipated impacts against the future without project condition (i.e., no project alternative). The recommended plan selected is the EQ plan, thus the impact discussion and display on TABLE B-44 simply shows the no action, NED, EQ/recommended and cycle three "conventional" plan effects. The cycle three "conventional" plan impacts are displayed as a means to providing information on the best alternative plan that makes no use of low level protectors. This display approach is also intended to provide an indication of the comprehensive range of alternatives studied and screened. The assessment and vital use of environmental, social, physical and economic impacts (and others) was integral to the entire iterative plan formulation process. The discussion and display that follows are simply provided as a means of recounting the plan formulation procedure in the hopes of making it more understandable to the reader, and to fulfill various regulatory requirements of other Federal Agencies. These effects are discussed in the following paragraphs under the headings of physical, biological, and cultural impacts. In general, only significant impacts likely to influence the planning decisions and selection of the draft recommended plan are discussed. This includes a finding of no net impact on certain resources that must be considered because of environmental policies or regulations. TABLE B-44 the "Systems of Accounts," may provide assistance in the determination of impacts. TABLE B-44 displays for the alternative future scenarios the impacts on "timing," "uncertainty," "exclusivity" and "actuality." The display is organized to show these four impacts in the order listed above within four sets of brackets under each appropriate account in TABLE B-44. An explanation of the four impacts and their notation system follows:

TABLE B-44
MALINE CREEK
SYSTEM OF ACCOUNTS

ACCOUNTS	A - NO PROJECT ALTERNATIVE NO ACTION LOCATION OF IMPACTS Study Area	Region	Rest of Nation
1. National Economic Development			
a. *Beneficial Impacts*			
(1) Value of Increased Outputs of Goods and Services			
(a) Flood Damage Reduction	None	None	None
(b) Land Enhancement	None	None	None
(c) Recreation/ Environmental	None	None	None
(2) Value of Increased Output Resulting from External Economies	Not evaluated	Not evaluated	Not evaluated
(3) Value of Output from Use of Unemployed or Underemployed Labor Resources (NED Employment)	None	None	None

TABLE B-44 (Continued)
MALINE CREEK
SYSTEM OF ACCOUNTS

	A - NO PROJECT ALTERNATIVE		
	NO ACTION		
	LOCATION OF IMPACTS		
	Study Area	Region	Rest of Nation
(4) Total Beneficial Effects	None	None	None
b. Adverse Impacts			
(1) Project Costs - Flood Damage	$4,145,000 AA Damages (1, 2, 3), (6), (8), (9)	$4,145,000 AA Damages	$4,145,000 AA Damages
(a) Recreation/Environmental	Complete loss of high quality habitat (3), (5), (8), (9)	Continued loss to region	Continued loss to nation
(b) Operation, Mainteance and Replacement	Emergency Preparation and relief costs (1, 2, 3), (6), (8), (9)	Emergency preparation and relief costs	Emergency preparation and relief costs
(c) Loss of Productivity	Work lost due to flooding (1, 2, 3), (6), (8), (9)	Work lost due to flooding	Work lost due to flooding
(2) Losses Resulting from External Diseconomies	Not evaluated	Not evaluated	Not evaluated
(3) Total Adverse Effects	Substantial	Moderate losses	Minor l[illegible]
2. Environmental Quality			
a. EQ Enhanced			
*(1) Man-made Resources	State and local projects only	State and l[illegible] projects only	Sta[illegible] projects [illegible]

TABLE B-44 (Continued)
MALINE CREEK
SYSTEM OF ACCOUNTS

	A - NO PROJECT ALTERNATIVE		
	NO ACTION		
	LOCATION OF IMPACTS		
	Study Area	Region	Rest of Nation
*(2) Natural Resources			
*(a) Air Quality	No change	No change	No change
*(b) Water Quality	*Continued degredation (non point source)* (2), (5), (8), (9)	Continued degradation (non point)	PL 92-500 applies
(c) Land Quality	Minor erosion (1, 2, 3), (5), (8), (9)	Minor erosion	Insignificant
(d) Aquatic Ecosystems	*Nearly destroyed*	Losses to region	National policy applies
(e) Terrestrial Ecosystems	Eventual loss of habitat (1, 2, 3), (6), (8), (9)	Losses to region	National policy applies
(f) Threatened & Endangered Species	None	Not evaluated	Endangered Species Act applies
(3) Historic Structures	None affected	None affected	None affected
(4) Noise	65 dBA's average urban neighborhood	65 dBA's average urban neighborhood	N.A.
b. EQ Degraded			
*(1) Man-made Resources	State and local project only	State and local project only	N.A.

TABLE B-44 (Continued)
MALINE CREEK
SYSTEM OF ACCOUNTS

	A - NO PROJECT ALTERNATIVE		
	NO ACTION		
	LOCATION OF IMPACTS		
	Study Area	Region	Rest of Nation
*(2) Natural Resources			
*(a) Air Quality	No change	No change	Clean Air Act applies
*(b) Water Quality	Complete loss (2), (5), (8), (9)	Negative impact	PL 92-500 applies
(c) Land Quality	Minor erosion (1, 2, 3), (5), (8), (9)	Minor change	N.A.
(d) Aquatic Ecosystems	Complete degredation (1, 2, 3), (6), (8), (9)	Negative impact	National policy applies
(e) Terrestrial ecosystems	Eventual complete loss of habitat (1, 2, 3), (6), (8), (9)	Negative impact	National policy applies
(f) Threatened & Endangered Species	None	Not evaluated	Endangered Species Act applies
(3) Historic Structures	None affected	None affected	N.A.
(4) Noise	65 dBA's average urban neighborhood	65 dBA's average urban neighborhood	N.A.
c. EQ Destroyed			
*(1) Man-made Resources	Flooding of homes and utilities (1, 2, 3), (6), (8), (9)	Flooding of homes and utilities	N.A.

TABLE B-44 (Continued)
MALINE CREEK
SYSTEM OF ACCOUNTS

	A - NO PROJECT ALTERNATIVE		
	NO ACTION		
	LOCATION OF IMPACTS		
	Study Area	Region	Rest of Nation
*(2) Natural Resources			
*(a) Air Quality	No change	No change	Clean Air Act applies
*(b) Water Quality	Complete degredation (2), (5), (8), (9)	Negative impact	PL 92-500 applies
*(c) Land Quality	Minor erosion continues (1, 2, 3), (5), (8), (9)	Negative impact	N.A.
(d) Aquatic Ecosystems	Complete degredation (1, 2, 3), (6), (8), (9)	Negative impact	National policy applies
(e) Terrestrial Ecosystems	Continued degredation (1, 2, 3), (6), (8), (9)	Negative impact	National policy applies
(f) Threatened & Endangered Species	None	Not evaluated	Endangered Species Act applies
(3) Historic Structures	None affected	None affected	National policy applies
(4) Noise	65 dBA's average urban neighborhood	65 dBA's average urban neighborhood	N.A.

3. Social Well-being

a. Beneficial Impacts

TABLE B-44 (Continued)
MALINE CREEK
SYSTEM OF ACCOUNTS

	A - NO PROJECT ALTERNATIVE		
	NO ACTION LOCATION OF IMPACTS		
	Study Area	Region	Rest of Nation
*(1) Community Cohesion	Disruption due to flooding (1, 2, 3), (6), (8), (9)	Disruption due to flooding	N.A.
*(2) Community Growth	Hampered by flooding (1, 2, 3), (6), (8), (9)	Hampered by flooding	N.A.
*(3) Displacements	None	None	N.A.
(4) Real Income Distribution	None	None	N.A.
(5) Educational, Cultural, and Recreational Opportunies	Continued degredation of EQ/Shortage of 943 Rec acres by 2040 (1, 2, 3), (5), (8), (9)	Continued degradation of EQ/Shortage of 943 Rec acres by 2020	N.A.
(6) Security of Life, Health, and Safety	High risk from SPF flood (1, 2, 3), (5), (8), (9)	High risk from SPF flood	N.A.
*(7) Aesthetics	Not quantified	Not quantified	N.A.
*(8) Noise	65 dBA's average urban neighborhood	65 dBA's urban neighborhood	N.A.
b. Adverse Impacts			
(1) Community Cohesion	Disrupted due to flooding (1, 2, 3), (6), (8), (9)	Disrupted due to flooding	N.A.
*(2) Community Growth	Hampered by flooding (1, 2, 3), (6), (8), (9)	Hampered by flooding	N.A.

TABLE B-44 (Continued)
MALINE CREEK
SYSTEM OF ACCOUNTS

	A - NO PROJECT ALTERNATIVE		
	NO ACTION		
	LOCATION OF IMPACTS		
	Study Area	Region	Rest of Nation
*(3) Displacements	No impact	No impact	N.A.
(4) Real Income Distribution	No impact	No impact	N.A
(5) Educational, Cultural, and Recreational Opportunities	Shortage of 943 Rec acres by 2040 (1, 2, 3), (5), (8), (9)	Shortage of 943 Rec acres by 2020	N.A.
(6) Security of Life, Health, and Safety	High risk from SPF flood (1, 2, 3), (5), (8), (9)	High risk from SPF flood	N.A.
*(7) Aesthetics	Not quantified	Not quantified	N.A.
*(8) Noise	65 dBA's average urban neighborhood	65 dBA's average urban neighborhood	N.A.
4. Regional Development			
a. Beneficial Impacts			
(1) Income	Losses due to flooding (1, 2, 3), (6), (8), (9)	Losses due to flooding	N.A.
*(2) Employment	Potentially hampered by flooding	Potentially hampered by flooding.	N.A.
*(3) Property Values	Average $1,800 structure loss of value in F.P. (1, 2, 3), (5), (8), (9)	Average $1,800 structure loss of value in F.P.	N.A.

TABLE B-44 (Continued)
MALINE CREEK
SYSTEM OF ACCOUNTS

	A - NO PROJECT ALTERNATIVE		
	NO ACTION		
	LOCATION OF IMPACTS		
	Study Area	Region	Rest of Nation
*(4) Tax Revenues			
(5) Population Distribution	No change	No change	N.A.
*(6) Regional Growth	Hampered by flooding (1, 2, 3), (6), (8), (9)	Hampered by flooding	N.A.
*(7) Cash Contribution	N.A.	N.A.	N.A.
*(8) Public Facilities & Services	State/Local projects	State/local projects	N.A.
*(9) Business & Industry	No basic change in trends	No basic change in trends	N.A.
*(10) Displacement of Farms & Residences	None	None	N.A.
B. Adverse Impacts			
(1) Income	Losses due to flooding (1, 2, 3), (6), (8), (9)	Losses due to flooding	N.A.
(a) Project Construction	N.A.	N.A.	N.A.
(b) Operation, Maintenance, and Replacement	N.A.	N.A.	N.A.

TABLE B-44 (Continued)
MALINE CREEK
SYSTEM OF ACCOUNTS

	A - NO PROJECT ALTERNATIVE		
	NO ACTION		
	LOCATION OF IMPACTS		
	Study Area	Region	Rest of Nation
*(2) Employment	5.2% unemployment	5.2% unemployment	±7.0% unemployment
*(3) Property Values	Property in F.P. depressed by $1,800/ structure (1, 2, 3), (5), (8), (9)	Property in F.P. depressed by $1,800/ structure	N.A.
*(4) Tax Revenues	Continued fiscal problems	Continued fiscal problems	N.A.
(5) Population Distribution	No change	No change	N.A.
(6) Regional Growth	Hampered by flooding (1, 2, 3), (6), (8), (9)	Hampered by flooding	None
*(7) Cash Contribution	N.A.	N.A.	N.A.
*(8) Public Facilities & Services	State/local projects	State/local projects	N.A.
(9) Business & Industry	No basic change in trends	No basic change in trends	N.A.
*(10) Displacement of Farms & Residences	None	None	N.A.

TABLE B-44 (Continued)
MALINE CREEK
SYSTEM OF ACCOUNTS

ACCOUNTS	B - RECOMMENDED PLAN/EQ PLAN(2)		
	LOCATION OF IMPACTS		
	Study Area(1)	Region	Rest of Nation
1. National Economic Development			
a. Beneficial Impacts			
(1) Value of Increased Outputs of Goods and Services			
(a) Flood Damage Reduction	$3,718,400 A.A. (1, 2, 3), (6), (7), (10)	$3,718,400 A.A.	$3,718,400 A.A.
(b) Land Enhancement	Not quantified	Not quantified	Not quantified
(c) Recreation/ Environmental	5 fish ponds, 18 habitat structures, + 858 Rec Ac $1,059,000 A.A. (1, 2, 3), (6), (7), (10)	5 fish ponds, 18 habitat structures, + 858 Rec Ac $1,059,000 A.A.	$1,059,000 A.A.
(2) Value of Increased Output Resulting from External Economies	Not evaluated	Not evaluated	Not evaluated
(3) Value of Output from Use of Unemployed or Underemployed Labor Resources (NED Employment)	No eligible areas	No eligible areas	No eligible areas

(1) Timing, certainty, exclusivity, and completeness shown in column (1) also apply to columns (2) and (3).
(2) N.A. indicates not applicable.

TABLE B-44 (Continued)
MALINE CREEK
SYSTEM OF ACCOUNTS

	B - RECOMMENDED PLAN/EQ PLAN		
	LOCATION OF IMPACTS		
	Study Area	Region	Rest of Nation
(4) Total Beneficial Effects	$4,777,400 A.A. (1, 2, 3), (5), (8), (11)	$4,777,400 A.A.	$4,777,000 A.A.
b. Adverse Impacts			
(1) Project Costs - Flood Damage	$2,785,200 (1), (6), (7), (9)	$2,785,200	$2,785,200
(a) Recreation/ Environmental	$447,200 A.A. (1, 2, 3), (5), (8), (10)	$447,200 A.A.	$447,200 A.A.
(b) Operation, Mainteance	$450,000 (Included in 1, 1a above)	$450,000	$450,000
(c) Loss of Productivity	None	None	None
(2) *Losses Resulting from* External Diseconomies	*Not evaluated*	*Not evaluated*	*Not evaluated*
(3) Total Adverse Effects	$3,232,400 (1), (6), (7), (9)	$3,232,400	$3,232,400
2. Environmental Quality			
a. EQ Enhanced			
*(1) Man-made Resources	8-dry detentions and related Rec Resources (2, 3), (5), (8), (11)	8-dry detentions and related Rec Resources	8-dry detentions and related Rec Resources

TABLE B-44 (Continued)
MALINE CREEK
SYSTEM OF ACCOUNTS

	B - RECOMMENDED PLAN/EQ PLAN		
	LOCATION OF IMPACTS		
	Study Area	Region	Rest of Nation
*(2) Natural Resources			
*(a) Air Quality	Slight, localized due to construction (1), (6), (8), (11)	Slight, localized due construction	Clean Air Act supported
*(b) Water Quality	18 habitat control structures, erosion control and oxygenation (1, 2, 3), (5), (8), (10)	18 habitat control structures, erosion control and oxygenation	PL 92-500 supported
(c) Land Quality	No basic change	No basic change	
(d) Aquatic Ecosystems	5 fish ponds (1, 2, 3), (6), (8), (11)	5 fish ponds	National goals supported
(e) Terrestrial Ecosystems	18 high grade habitat areas preserved (1, 2, 3), (6), (8), (11)	18 high grade habitat areas preserved	National goals supported
(f) Threatened & Endangered Species	None	Not evaluated	Endangered Species Act supported
(3) Historic Structures	None	None	Historic Preservation Act supported
(4) Noise	84 dBA's - short-term construction period (1), (6), (8), (11)	84 dBA's - short-term construction period	N.A.
b. EQ Degraded			

TABLE B-44 (Continued)
MALINE CREEK
SYSTEM OF ACCOUNTS

	B - RECOMMENDED PLAN/EQ PLAN		
	LOCATION OF IMPACTS		
	Study Area	Region	Rest of Nation
*(1) Man-made Resources	19 ac out of production for EQ purposes (1, 2, 3), (5), (8), (11)	19 ac out of production for EQ purposes	National Policy supported
*(2) Natural Resources			
*(a) Air Quality	Slight, localized due to construction (1), (6), (8), (11)	Slight, localized due to construction	Clean Air Act supported
*(b) Water Quality	No degradation	Decreased degradation	PL 92-500 supported
(c) Land Quality	No basic change	No basic change	N.A.
(d) Aquatic Ecosystems	No degradation	No degradation	National goals supported
(e) Terrestrial ecosystems	No degradation	No degradation	National goals supported
(f) Threatened & Endangered Species	None	Not evaluated	Endangered Species supported
(3) Historic Structures	None endangered	None endangered	Historic Preservation Act supported
(4) Noise	84 dBA's - short-term construction period (1), (6), (8), (11)	84 dBA's - short-term construction period	N.A.

TABLE B-44 (Continued)
MALINE CREEK
SYSTEM OF ACCOUNTS

B - RECOMMENDED PLAN/EQ PLAN

LOCATION OF IMPACTS

	Study Area	Region	Rest of Nation
c. EQ Destroyed			
*(1) Man-made Resources	None destroyed	None destroyed	National Policy supported
*(2) Natural Resources			
*(a) Air Quality	Slight, localized due to construction (1), (6), (8), (11)	Slight, localized due to construction	Clean Air Act supported
*(b) Water Quality	None degradated	None degradated	PL 92-500 supported
*(c) Land Quality	No basic change	No basic change	N.A.
(d) Aquatic Ecosystems	None degradated	None degradated	National [illegible] supported
(e) Terrestrial Ecosystems	None degradated	None degradated	National [illegible] supported
(f) Threatened & Endangered Species	None	Not evaluated	Endangered Species Act supported
(3) Historic Structures	None endangered	None endangered	Historic Preservation Act supported

TABLE B-44 (Continued)
MALINE CREEK
SYSTEM OF ACCOUNTS

	B - RECOMMENDED PLAN/EQ PLAN		
	LOCATION OF IMPACTS		
	Study Area	Region	Rest of Nation
(4) Noise	84 dBA's due to construction (1), (6), (8), (11)	84 dBA's due to construction	N.A.
3. Social Well-being			
a. Beneficial Impacts			
*(1) Community Cohesion	Improved (90% damage reduction) (1, 2, 3), (5), (8), (11)	Improved (90% damage reduction)	National Policy supported
*(2) Community Growth	$77,200,000 new business activity (1), (5), (8), (11)	$77,200,000 new businecss activity	National Policy supported
*(3) Displacements	74 structures (1), (5), (8), (11)	74 structures	National Policy supported
(4) Real Income Distribution	Not evaluated	Not evaluated	Not evaluated
(5) Educational, Cultural, and Recreational Opportunies	272,700 Rec user days generated (1, 2, 3), (5), (8), (10)	272,700 Rec user days generated	National goals supported
(6) Security of Life, Health, and Safety	Damage from SPF flood reducted by 27% (3), (5), (8), (11)	Damage from SPF flood reduced by 27%	National goals supported
*(7) Aesthetics	Not quantified	Not quantified	Not quantified

TABLE B-44 (Continued)
MALINE CREEK
SYSTEM OF ACCOUNTS

	B - RECOMMENDED PLAN/EQ PLAN		
	LOCATION OF IMPACTS		
	Study Area	Region	Rest of Nation
*(8) Noise	84 dBA's due to construction (1), (6), (8), (11)	84 dBA's due to construction	N.A.
b. Adverse Impacts			
(1) Community Cohesion	No adverse impacts	No adverse impacts	National goals supported
*(2) Community Growth	No adverse impacts	No adverse impacts	National Policy supported
*(3) Displacements	74 structures (1), (5), (8), (11)	74 structures	National Policy supported
(4) Real Income Distribution	Not evaluated	Not evaluated	Not evaluated
(5) Educational, Cultural, and Recreational Opportunities	No adverse impacts	No adverse impacts	National goals supported
(6) Security of Life, Health, and Safety	Risks still exist (3), (5), (8), (11)	Risks still exist	National goals supported
*(7) Aesthetics	Not quantified	Not quantified	Not quantified
*(8) Noise	84 dBA's due to construction (1), (6), (8), (11)	84 dBA's due to construction	N.A.

TABLE B-44 (Continued)
MALINE CREEK
SYSTEM OF ACCOUNTS

	B - RECOMMENDED PLAN/EQ PLAN		
	LOCATION OF IMPACTS		
	Study Area	Region	Rest of Nation
4. Regional Development			
a. Beneficial Impacts			
(1) Income	$77,200,000 new business activity (1), (5), (8), (11)	$77,200,000 new business activity	National goals supported
*(2) Employment	1,533 man-years generated (1), (5), (8), (11)	1,533 man-years generated	National policy supported
*(3) Property Values	$1,500 increase to homes in F.P. (1), (5), (8), (11)	$1,500 increase to homes in F.P.	National Policy supported
*(4) Tax Revenues	$770,000 due to sales tax (1), (5), (8), (11)	$770,000 due to sales tax	National Policy supported
(5) Population Distribution	Not evaluated	Not evaluated	Not evaluated
*(6) Regional Growth	$77,200,000 new business activity (1), (5), (8), (11)	$77,200,000 new business activity	National Policy supported
*(7) Cash Contribution	Not evaluated	Not evaluated	Not evaluated
*(8) Public Facilities & Services	8 dry dententions/rec areas/trails (2,3), (5), (8), (11)	8 dry detentions/rec areas/trails	National Policy supported
*(9) Business & Industry	$77,200,000 new business activity (1), (5), (8), (11)	$77,200,000 new business activity	National Policy supported

TABLE B-44 (Continued)
MALINE CREEK
SYSTEM OF ACCOUNTS

	B - RECOMMENDED PLAN/EQ PLAN		
	LOCATION OF IMPACTS		
	Study Area	Region	Rest of Nation
*(10) Displacement of Farms & Residences	74 structures (1), (5), (8), (11)	74 structures	National Policy supported
b. Adverse Impacts			
(1) Income	No adverse impact	No adverse impact	National goals supported
*(2) Employment	No adverse impact	No adverse impact	National Policy supported
*(3) Property Values	No adverse impact	No adverse impact	National Policy supported
*(4) Tax Revenues	No adverse impact	No adverse impact	National Policy supported
(5) Population Distribution	Not evaluated	Not evaluated	Not evaluated
(6) Regional Growth	No adverse impact	No adverse impact	National goals supported
*(7) Cash Contribution	Not evaluated	Not evaluated	Not evaluated
*(8) Public Facilities & Services	19 ac out of production for EQ purposes (1, 2, 3), (5), (8), (11)	19 ac out of production for EQ purposes	National Policy supported

TABLE B-44 (Continued)
MALINE CREEK
SYSTEM OF ACCOUNTS

	B - RECOMMENDED PLAN/EQ PLAN		
	LOCATION OF IMPACTS		
	Study Area	Region	Rest of Nation
(9) Business & Industry	1 commercial displacement (1), (5), (8), (11)	1 commercial displacement	National goals supported
*(10) Displacement of Farms & Residences	74 structures (1), (5), (8), (11)	74 structures	National Policy supported

TABLE B-44 (Continued)
MALINE CREEK
SYSTEM OF ACCOUNTS

ACCOUNTS	C. NED PLAN — LOCATION OF IMPACTS: Study Area	Region	Rest of Nation
1. National Economic Development			
a. Beneficial Impacts			
(1) Value of Increased Outputs of Goods and Services			
(a) Flood Damage Reduction	$3,822,000 A.A. (1, 2, 3), (6), (7), (10)	$3,822,000 A.A.	$3,822,000 A.A.
(b) Land Enhancement	Not quantified	Not quantified	Not quantified
(c) Recreation/ Environmental	858 Rec ac $1,059,000 A.A. (1, 2, 3), (6), (7), (10)	858 Rec ac $1,059,000 A.A.	858 Rec ac $1,059,000 A.A.
(2) Value of Increased Output Resulting from External Economies	Not evaluated	Not evaluated	Not evaluated
(3) Value of Output from Use of Unemployed or Underemployed Labor Resources (NED Employment)	No eligible areas (1), (6), (8), (11)	No eligible areas	No eligible areas
(4) Total Beneficial Effects	$4,881,000 (1, 2, 3), (5), (8), (11)	$4,881,000	$4,881,000

TABLE B-44 (Continued)
MALINE CREEK
SYSTEM OF ACCOUNTS

	C. NED PLAN		
	LOCATION OF IMPACTS		
	Study Area	Region	Rest of Nation
b. Adverse Impacts			
(1) Project Costs	$2,642,600 (1), (6), (7), (9)	$2,642,600	$2,642,600
(a) Recreation/ Environmental	$343,900 A.A. (1, 2, 3), (5), (8), (9)	$343,900	$343,900
(b) Operation, Maintenance, & Replacement	$408,000	$408,000	$408,000
(c) Loss of Productivity	None	None	None
(2) Losses Resulting from External Diseconomies	Not evaluated	Not evaluated	Not evaluated
(3) Total Adverse Effects	$3,394,500 (1), (6), (7), (9)	$3,394,500	$3,394,500
2. Environmental Quality			
a. EQ Enhanced			
*(1) Man-made Resources	8 dry detentions and related rec resources (2, 3), (5), (8), (11)	8 dry detentions and related rec resources	8 dry detentions and related rec resources
*(2) Natural Resources			

TABLE B-44 (Continued)
MALINE CREEK
SYSTEM OF ACCOUNTS

C. NED PLAN

	LOCATION OF IMPACTS		
	Study Area	Region	Rest of Nation
*(a) Air Quality	Slight, localized due to construction (1), (6), (8), (11)	Slight, localized due to construction	Clean Air Act supported
*(b) Water Quality	18 habitat control structures, erosion control and oxygenation (1, 2, 3), (5), (8), (11)	18 habitat control structures, erosion control and oxygenation	PL 92-500 supported
(c) Land Quality	No major impact	No major impact	N.A.
(d) Aquatic Ecosystems	No fish ponds	No fish ponds	National goals supported
(e) Terrestrial Ecosystems	No improvement provided	No improvement provided	National goals supported
(f) Threatened & Endangered Species	None	Not evaluated	Endangered Species Act supported
(3) Historic Structures	None endangered	None endangered	Historic Preservation Act supported
(4) Noise	84 dBA's - short-term construction period (1), (6), (8), (11)	84 dBA's - short-term construction period	N.A.

b. EQ Degraded

TABLE B-44 (Continued)
MALINE CREEK
SYSTEM OF ACCOUNTS

	C. NED PLAN		
	LOCATION OF IMPACTS		
	Study Area	Region	Rest of Nation
*(1) Man-made Resources	None	None	National Policy *not* supported
*(2) Natural Resources			
*(a) Air Quality	Slight, localized due to construction (1), (6), (8), (11)	Slight, localized due to construction	Clean Air Act supported
*(b) Water Quality	No degradation	No degradation	PL 92-500 supported
(c) Land Quality	No basic change	No basic change	N.A.
(d) Aquatic Ecosystems	No degradation	No degradation	National goals supported
(e) Terrestrial Ecosystems	No degradation	No degradation	National goals supported
(f) Threatened & Endangered Species	None	Not evaluated	Endangered Species supported
(3) Historic Structures	None endangered	None endangered	Historic Preservation Act supported
(4) Noise	84 dBA's - short-term construction period (1), (6), (8), (11)	84 dBA's - short-term construction period	N.A.

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TABLE B-44 (Continued)
MALINE CREEK
SYSTEM OF ACCOUNTS

C. NED PLAN

	LOCATION OF IMPACTS		
	Study Area	Region	Rest of Nation
c. EQ Destroyed			
*(1) Man-made Resources	None destroyed	None destoryed	National Policy supported
*(2) Natural Resources			
*(a) Air Quality	Slight, localized due to construction (1), (6), (8), (11)	Slight, localized due to construction	Clean Air Act supported
*(b) Water Quality	None degraded	None degraded	PL 92-500 supported
*(c) Land Quality	No basic change	No basic change	N.A.
(d) Aquatic Ecosystems	None degraded	None degraded	National goals supported
(e) Terrestrial Ecosystems	Non degraded	None degraded	National goals supported
(f) Threatened & Endangered Species	None	Not evaluated	Endangered Species Act supported
(3) Historic Structures	None endangered	None endangered	Historic Preservation Act supported

TABLE B-44 (Continued)
MALINE CREEK
SYSTEM OF ACCOUNTS

	C. NED PLAN		
	LOCATION OF IMPACTS		
	Study Area	Region	Rest of Nation
(4) Noise	84 dBA's - short-term due to construction (1), (6), (8), (11)	84 dBA's - short-term due to construction	N.A.
3. Social Well-being			
a. Beneficial Impacts			
*(1) Community Cohesion	Improved (92% damage reduction) (1, 2, 3), (5), (8), (11)	Improved (92% damage reduction	National Policy supported
*(2) Community Growth	$77,200,000 new business activity (1), (5), (8), (11)	$77,200,000 new business activity	National Policy supported
*(3) Displacements	74 structures (1), (5), (8), (11)	74 structures	National Policy supported
(4) Real Income Distribution	Not evaluated	Not evaluated	Not evaluated
(5) Educational, Cultural, and and Recreational Opportunities	272,700 users days generated (1, 2, 3), (5), (8), (10)	272,700 user days generated	National goals supported
(6) Security of Life, Health, and Safety	Damage from SPF flood reduced by 26% (3), (5), (8), (11)	Damage from SPF flood reduced by 26%	National goals supported

TABLE B-44 (Continued)
MALINE CREEK
SYSTEM OF ACCOUNTS

	C. NED PLAN		
	LOCATION OF IMPACTS		
	Study Area	Region	Rest of Nation
*(7) Aesthetics	Not quantified	Not quantified	Not quantified
*(8) Noise	84 dBA's due to construction (1), (6), (8), (11)	84 dBA's due to construction	N.A.
b. Adverse Impacts			
(1) Community Cohesion	No adverse impacts	No adverse impacts	National goals supported
*(2) Community Growth	No adverse impacts	No adverse impacts	National Policy supported
*(3) Displacements	74 structures (1), (5), (8), (11)	74 structures	National Policy supported
(4) Real Income Distribution	Not evaluated	Not evaluated	Not evaluated
(5) Educational, Cultural, and Recreational Opportunities	Recreation areas considered a hazard by some	Same	National goals supported
(6) Security of Life, Health, and Safety	Risk still exist (3), (5), (8), (11)	Risk still exist	National goal supported
*(7) Aesthetics	Not quantified	Not quantified	Not quantified

TABLE B-44 (Continued)
MALINE CREEK
SYSTEM OF ACCOUNTS

C. NED PLAN

	LOCATION OF IMPACTS		
	Study Area	Region	Rest of Nation
*(8) Noise	84 dBA's due to construction (1), (6), (8), (11)	84 dBA's due to construction	N.A.
4. Regional Development			
a. Beneficial Impacts			
(1) Income	$77,200,000 new business activity (1), (5), (8), (11)	$77,200,000 new business activity	National goals supported
*(2) Employment	1,533 man-years generated (1), (5), (8), (11)	1,533 man-years generated	National Policy supported
*(3) Property Values	$1,500 increase to homes in F.P. (1), (5), (8), (11)	$1,500 increase to homes in F.P.	National Policy supported
*(4) Tax Revenues	$770,000 due to sales tax (1), (5), (8), (11)	$770,000 due to sales tax	National Policy supported
(5) Population Distribution	Not evaluated	Not evaluated	Not evaluated
*(6) Regional Growth	$77,200,000 new business activity (1), (5), (8), (11)	$77,200,000 new business activity	National Policy supported

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TABLE B-44 (Continued)
MALINE CREEK
SYSTEM OF ACCOUNTS

	C. NED PLAN		
	LOCATION OF IMPACTS		
	Study Area	Region	Rest of Nation
*(7) Cash Contribution	Not evaluated	Not evaluated	Not evaluated
*(8) Public Facilities & Services	8 dry detentions/rec areas/trails	8 dry detentions/rec areas/trails	National Policy supported
*(9) Business & Industry	$77,200,000 new business activity (1), (5), (8), (11)	$77,200,000 new business activity	National Policy supported
*(10) Displacement of Farms & Residences	74 structures (1), (5), (8), (9)	74 structures	National Policy supported
b. Adverse Impacts			
(1) Income	No adverse impacts	No adverse impacts	National goals supported
*(2) Employment	No adverse impacts	No adverse impacts	National Policy supported
*(3) Property Values	No adverse impacts	No adverse impacts	National Policy supported
*(4) Tax Revenues	No adverse impacts	No adverse impacts	National Policy supported

TABLE B-44 (Continued)
MALINE CREEK
SYSTEM OF ACCOUNTS

	C. NED PLAN		
	LOCATION OF IMPACTS		
	Study Area	Region	Rest of Nation
(5) Population Distribution	Not evaluated	Not evaluated	Not evaluated
(6) Regional Growth	No adverse impacts	No adverse impacts	National goals supported
*(7) Cash Contribution	Not evaluated	Not evaluated	Not evaluated
*(8) Public Facilities & Services	No adverse impacts	No adverse impacts	National Policy supported
(9) Business & Industry	1 commercial displaced (1), (5), (8), (11)	1 commercial displaced	National goals supported
*(10) Displacement of Farms & & Residences	74 structures (1), (5), (8), (11)	74 structures	74 structures

TABLE B-44 (Continued)
MALINE CREEK
SYSTEM OF ACCOUNTS

ACCOUNTS	D. CYCLE THREE "CONVENTIONAL" PLAN — LOCATION OF IMPACTS: Study Area	Region	Rest of Nation
1. National Economic Development			
a. Beneficial Impacts			
(1) Value of Increased Outputs of Goods and Services			
(a) Flood Damage Reduction	$2,891,000 A.A. (1, 2, 3), (5), (8), (11)	$2,891,000 A.A.	$2,891,000 A.A.
(b) Land Enhancement	Not quantified	Not quantified	Not quantified
(c) Recreation/ Environmental	$1,059,000 A.A.	$1,059,000 A.A.	$1,059,000 A.A.
(2) Value of Increased Output Resulting from External Economies	Not evaluated	Not evaluated	Not evaluated
(3) Value of Output from Use of Unemployed or Underemployed Labor Resources (NED Employment)	No eligible areas	No eligible areas	No eligible areas
(4) Total Beneficial Effects	$3,950,000 A.A. (1, 2, 3), (5), (8), (11)	$3,950,000 A.A.	$3,950,000 A.A.

TABLE B-44 (Continued)
MALINE CREEK
SYSTEM OF ACCOUNTS

D. CYCLE THREE "CONVENTIONAL" PLAN

	LOCATION OF IMPACTS		
	Study Area	Region	Rest of Nation
b. Adverse Impacts			
(1) Project Costs	$2,253,300 (1), (6), (7), (9)	$2,253,300	$2,253,300
(a) Recreation/ Environmental	$642,000 A.A. (1, 2, 3), (5), (8), (9)	$642,000	$642,000
(b) Operation, Maintenance, & Replacement	$341,000	$341,000	$341,000
(c) Loss of Productivity	None	None	None
(2) Losses Resulting from External Diseconomies	Not evaluated	Not evaluated	Not evaluated
(3) Total Adverse Effects	$3,236,300 A.A. (1), (6), (7), (9)	$3,236,300 A.A.	$3,236,300 A.A.
2. Environmental Quality			
a. EQ Enhanced			
*(1) Man-made Resources	8 dry detentions and related rec resources (2, 3), (5), (8), (11)	8 dry detentions and related rec resources	8 dry detentions and related rec resources
*(2) Natural Resources			

TABLE B-44 (Continued)
MALINE CREEK
SYSTEM OF ACCOUNTS

	[illegible]		
	Location of Impacts		
	Study Area	Region	Rest of Nation
*(a) Air Quality	Slight, localized due to construction (1), (6), (8), (11)	Slight, localized due to construction	Clean Air Act supported
*(b) Water Quality	PL 92-500 supported	PL 92-500 supported	PL 92-500 supported
(c) Land Quality	No basic change	No basic change	No basic change
(d) Aquatic Ecosystems	3 aquatic habitat structures, 5 fish ponds (1, 2, 3), (6), (8), (11)	3 aquatic habitat structures, 5 fish ponds	National goals supported
(e) Terrestrial Ecosystems	35 acres lost to construction (1, 2, 3), (5), (8), (11)	35 acresg lost to construction	National goals supported
(f) Threatened & Endangered Species	None	None	Endangered Species Act supported
(3) Historic Structures	None	None	Historic Preservation Act supported
(4) Noise	85 dBA's - short-term construction period (1), (6), (8), (11)	85 dBA's - short-term construction period	N.A.

b. EQ Degraded

TABLE B-44 (Continued)
MALINE CREEK
SYSTEM OF ACCOUNTS

D. CYCLE THREE "CONVENTIONAL" PLAN

	LOCATION OF IMPACTS		
	Study Area	Region	Rest of Nation
*(1) Man-made Resources	None	None	National Policy not supported
*(2) Natural Resources			
*(a) Air Quality	Slight, localized due to construction (1), (6), (8), (11)	Slight, localized due to construction	Clean Air Act supported
*(b) Water Quality	No degradation	No degradation	PL 92-500 supported
(c) Land Quality	No basic change	No basic change	N.A.
(d) Aquatic Ecosystems	3 aquatic habitat structures, 5 fish ponds (1, 2, 3), (5), (8), (11)	3 aquatic habitat structures, 5 fish ponds	National Goals Supported
(e) Terrestrial Ecosystems	35 acres lost to construction (1, 2, 3), (5), (8), (11)	35 acres lost to construction	National goals supported
(f) Threatened & Endangered Species	None	None	Endangered Species Act supported
(3) Historic Structures	None	None	Historic Preservation Act Supported
(4) Noise	85 dBA's - short-term construction period (1), (6), (8), (11)	85 dBA's - short-term construction period	N.A.

TABLE B-44 (Continued)
MALINE CREEK
SYSTEM OF ACCOUNTS

	Study Area	Region	Rest of Nation
C. EQ Destroyed			
*(1) Man-made Resources	None destroyed	None destoryed	National Policy supported
*(2) Natural Resources			
*(a) Air Quality	Slight, localized due to construction (1), (6), (8), (11)	Slight, localized due to construction	Clean Air Act supported
*(b) Water Quality	No degradation	No degradation	PL 92-500 supported
*(c) Land Quality	No basic change	No basic change	N.A.
(d) Aquatic Ecosystems	No degradation	No degradation	National goals supported
(e) Terrestrial Ecosystems	No degradation	No degradation	National goals supported
(f) Threatened & Endangered Species	None	None	Endangered Species Act supported
(3) Historic Structures	None endangered	None endangered	Historic Preservation Act supported

TABLE B-44 (Continued)
MALINE CREEK
SYSTEM OF ACCOUNTS

C. NED PLAN

	LOCATION OF IMPACTS		
	Study Area	Region	Rest of Nation
(4) Noise	85 dBA's - short-term due to construction (1), (6), (8), (11)	85 dBA's - short-term due to construction period	N.A.
3. Social Well-being			
a. Beneficial Impacts			
*(1) Community Cohesion	Improved (70% damage reduction) (1, 2, 3), (5), (8), (11)	Improved (70% damage reduction	National Policy supported
*(2) Community Growth	$77,200,000 new business activity (1), (5), (8), (11)	$77,200,000 new business activity	National Policy supported
*(3) Displacements	19 residential and commercial structures (1), (5), (8), (11)	19 residential and commerical	National Policy supported
(4) Real Income Distribution	Not evaluated	Not evaluated	Not evaluated
(5) Educational, Cultural, and and Recreational Opportunities	272,700 rec. users days generated (1, 2, 3), (5), (8), (10)	272,700 rec. [illegible] generated	[illegible]
(6) Security of Life, Health, and Safety	Damage from SPF flood reduced by 15% (3), (5), (8), (11)	Damage from SPF flood reduced by 15%	National [illegible]als supported

TABLE B-44 (Continued)
MALINE CREEK
SYSTEM OF ACCOUNTS

	Location of Impacts: Study Area	Region	Rest of Nation
*(7) Aesthetics	Not quantified	Not quantified	Not quantified
*(8) Noise	85 dBA's due to construction (1), (6), (8), (11)	85 dBA's due to construction	N.A.
b. Adverse Impacts			
(1) Community Cohesion	No adverse impacts	No adverse impacts	National goals supported
*(2) Community Growth	No adverse impacts	No adverse impacts	National Policy supported
*(3) Displacements	19 residential and commercial structures (1), (5), (8), (11)	19 residential and commercial	National Policy supported
(4) Real Income Distribution	Not evaluated	Not evaluated	Not evaluated
(5) Educational, Cultural, and Recreational Opportunities	No adverse impacts	No adverse impacts	National goals supported
(6) Security of Life, Health, and Safety	Risk still exist (3), (5), (8), (11)	Risk still exists	National goal supported
*(7) Aesthetics	Not quantified	Not quantified	Not quantified

TABLE B-44 (Continued)
MALINE CREEK
SYSTEM OF ACCOUNTS

D. CYCLE THREE "CONVENTIONAL" PLAN

	LOCATION OF IMPACTS		
	Study Area	Region	Rest of Nation
*(8) Noise	85 dBA's due to construction (1), (6), (8), (11)	85 dBA's due to construction	N.A.
4. Regional Development			
a. Beneficial Impacts			
(1) Income	$77,200,000 new business activity (1), (5), (8), (11)	$77,200,000 new business activity	National goals supported
*(2) Employment	1,533 man-years generated (1), (5), (8), (11)	1,533 man-years generated	National Policy supported
*(3) Property Values	$1,500 increase to homes in F.P. (1), (5), (8), (11)	$1,500 increase to homes in F.P.	National Policy supported
*(4) Tax Revenues	$770,000 due to sales tax (1), (5), (8), (11)	$770,000 due to sales tax	National Policy supported
(5) Population Distribution	Not evaluated	Not evaluated	Not evaluated
*(6) Regional Growth	$77,200,000 new business activity (1), (5), (8), (11)	$77,200,000 new business activity	National Policy supported

TABLE B-44 (Continued)
MALINE CREEK
SYSTEM OF ACCOUNTS

	D. CYCLE THREE "CONVENTIONAL" PLAN		
	LOCATION OF IMPACTS		
	Study Area	Region	Rest of Nation
*(7) Cash Contribution	Not evaluated	Not evaluated	Not evaluated
*(8) Public Facilities & Services	8 dry detentions/rec areas/trails (2, 3), (5), (8), (11)	8 dry detentions/rec areas/trails	National Policy supported
*(9) Business & Industry	$77,200,000 new business activity (1), (5), (8), (11)	$77,200,000 new business activity	National Policy supported
*(10) Displacement of *Farms &* Residences	*19 residential and commercial structures* (1), (5), (8), (11)	19 residential and commercial structures	National Policy supported
5. Adverse Impacts			
(1) Income	No adverse impacts	No adverse impacts	National goals supported
*(2) Employment	No adverse impacts	No adverse impacts	National Policy supported
*(3) Property Values	No adverse impacts	No adverse impacts	[illegible]
*(4) Tax Revenues	No adverse impacts	[illegible]	[illegible]

TABLE B-44 (Continued)
MALINE CREEK
SYSTEM OF ACCOUNTS

D. CYCLE THREE "CONVENTIONAL" PLAN

	LOCATION OF IMPACTS		
	Study Area	Region	[illegible] of Nation
(5) Population Distribution	Not evaluated	Not evaluated	Not evaluated
(6) Regional Growth	No adverse impacts	No adverse impacts	National goals supported
*(7) Cash Contribution	Not evaluated	Not evaluated	Not evaluated
*(8) Public Facilities & Services	8 dry detentions/ rec areas/trails (2, 3), (5), (8), (11)	8 dry detentions [illegible] areas/trails	[illegible]
(9) Business & Industry	13 commercial establishments relocated (1), (5), (8), (11)	13 commercial [illegible] ments relocated	[illegible]
*(10) Displacement of Farms & & Residences	19 residential and commercial structures (1), (5), (8), (11)	19 residential [illegible] commercial	[illegible]

a. Timing. The timing of an effect is a critical variable in plan formulation. The following notations are [illegible]

(1) A "1" will be used to designate impacts expected to occur prior to or during plan implementation.

(2) A "2" will be used to designate impacts expected in a short time frame. These will generally be impacts estimated to occur in 15 years or less after implementation of a plan.

(3) A "3" will be used to designate impacts expected in a long time frame. These will generally be impacts estimated to occur later than 15 years after implementation of a plan.

b. Uncertainty. The concept of uncertainty is a broad one. It encompasses two of the specified evaluation criteria (certainty and stability). A rigorous statistical analysis to establish certainty or stability is not required. This concept represents a judgmental balancing of the following factors: the sensitivity of the impact on plan recommendations, the data limitations inherent in either the assessment or evaluation of the impact, and limitations inherent in the theoretical framework or methodology. Based upon these factors, the following notations will be made recognizing that the percent designations are suggestive and are not intended to imply statistical rigor.

(1) A "4" will be used to designate that the level of uncertainty associated with an impact in the judgment of the analyst is greater than 50 percent. Many components of the regional account, second, and third order effects, and external economies and diseconomies will often fall into this notation.

(2) A "5" will be used to designate an uncertainty range of 10-50 percent.

(3) A "6" will be used to designate an uncertainty range of 0-10 percent, thus suggesting that the impact is virtually certain.

c. Exclusivity. The components of accounts are not mutually exclusive. There are two major areas where such no -exclusivity may distort the display of accounts.

(1) Regional Development. Regional components of the NED, EQ, and SWB accouants must sum to the national totals. This will avoid double counting of effects geographically.

(2) Double Classification of Monetary and Non-Monetary Effects. Some contributions are dollar quantifiable but deserve special handling as non-monetary contributions as well. For example, while elimination of land scour due to flood flows can be quantified in dollars and counted as an NED benefit, it should also be included as a positive contribution to the environmental account since it improves the quality of land resources. The following notations are used:

(a) The designation "7" will be used when the SWB, EQ, or RD contribution has been fully monetized and counted as an NED beneficial or adverse contribution.

(b) The designation "8" will be used when the SWB, EQ, or RD contribution has been partially monetized.

d. Actuality. Many of the contributions of plans depends upon the actions of others. The following notation will be used:

(1) A "9" will be used to designate that the contribution will likely occur without any action by any entiry other than the proposed implementing agency, normally the Corps, or the required action is extremely likely to occur through the economic or natural physical systems.

(2) A "10" will be used to designate that the achievement of the beneficial contribution requires positive governmental action, other than cost sharing, by another agency. The adverse contribution associated with this action can and likely will be prevented by Government action. This situation can be specified only when coordination indicates that the necessary action will be taken.

(3) An "11" will be used when coordination indicates that the action required by other agencies will not be forthcoming.

197. Impacts on the Physical Elements. The impacts on soils, water quality and air quality are shown in the following paragraphs.

198. Soils. Impacts on soils by the NED and EQ/recommended plans are shown below:

a. NED Plan.

(1) Adverse impacts. Possibly short-term erosion during construction.

(2) Beneficial impacts. Possibly long-term control of sheet erosion, because of preservation of undeveloped woodlands; control of stream bank erosion, from stabilization structures; control of bottom degradation, from grade control structures.

(3) Net impacts. Beneficial long-term control of sheet erosion, stream bank erosion, and bottom degradation.

b. EQ/Recommended Plan.

(1) Adverse impacts. Same as NED Plan.

(2) Beneficial impacts. Same as NED plan, except that in stream reaches M1 through M14 and MD1 the bottom degradation would be controlled by aquatic habitat structures.

(3) Net impacts. Essentially the same as the NED plan.

199. Water Quality. Impacts on water quality by the NED and EQ/recommended plans are shown below:

a. NED Plan.

(1) Adverse impacts. There would be a temporary increase in siltation during construction.

(2) Beneficial impacts. The preservation of undeveloped lands in the detention sites and along the stream corridor would serve to help control the entrance of undesirable nutrients and other pollutants into the stream. The detention basins would trap some silt, preventing it from entering the stream. In and along the creek channel, stream bank stabilization and grade control structures would help control siltation.

(3) Net impacts. The net impacts have not been quantified, but net long-term beneficial impacts are expected.

b. EQ/Recommended Plan.

(1) Adverse impacts. Same as NED Plan.

(2) Beneficial impacts. Same as NED Plan, except that in the creek channel, siltation would be controlled by aquatic habitat structures. In addition, the fish ponds at detention sites (MD1-1, MD2-2, MH1, M22, and M27) would trap some silt and prevent it from entering the creek. This would, of course, be an adverse impact on the fish ponds (not project induced), but it is hoped that maintenance of heavily wood vegetation on detention basin project lands in and adjacent to these ponds will control erosion and protect the ponds from excessive siltation.

(3) Net impacts. Same as NED Plan.

200. Air Quality. Impacts on air quality by the NED and EQ/recommended plans are shown below:

a. NED P'-

(1) Adverse impacts. There would be a temporary increase in dust and exhaust fumes from construction equipment during construction.

(2) Beneficial impacts. None anticipated.

(3) Net impacts. No long-term effect.

b. EQ/Recommended Plan.

(1) Adverse Impacts. Same as for NED plan.

(2) Beneficial Impacts. Same as for NED plan.

(3) Net Impacts. Same as for NED plan.

Prime and Unique Farmland. No impacts, inasmuch as no such resources are located in the project area.

201. Clean Water Act, Section 404 Guidelines. A complete discussion of the impact of detailed alternative plans on resources covered by the Clean Water Act of 1977 is included in Appendix J.

202. Impacts on Biological Elements. Impacts on the aquatic and terrestrial ecosystems are as follows:

203. Aquatic Ecosystem.

a. NED Plan.

(1) Adverse impacts. During construction, a temporary adverse impact would result from the smothering of some fish and other aquatic organisms, and the covering of their habitats, by silt. A long-term adverse impact would result from the degradation of habitat in the channel that would be straightened.

(2) Beneficial impacts. The destruction of aquatic habitat would be mitigated either by preserving the cutoff segments of stream in straightened channel reaches or by including aquatic habitat structures (riffle/pool areas) in the straightened reachs.

(3) Net impacts. No net adverse or beneficial impact on the aquatic ecosystem would be expected when all NED Plan measures are considered.

b. EQ/Recommended Plan.

(1) Adverse impacts. Same as NED Plan, except that the stream would be straightened in reaches M-8 and M-10 that would not be disturbed by the NED Plan.

(2) Beneficial impacts. The aquatic habitat diversity would be enhanced by the construction of 18 aquatic habitat structures at 0.5 mile invervals in stream reaches M1 through M14 and MD1. In addition, aquatic habitat diversity would be enhanced by the construction of 5 fish ponds, varying in size from 2 to 4 acres, at different detention sites.

(3) Net impacts. The beneficial impacts would more than compensate for adverse impacts, for a substantial net beneficial effect on the aquatic ecosystem.

204. Terrestrial Ecosystem.

a. NED Plan.

(1) Adverse impacts. A total of 73 acres of terrestrial wildlife habitat would be cleared to permit the installation of flood control structures and outdoor recreation facilities. Wildlife communities in adjacent habitat areas would be temporarily disrupted during construction. Further disruption would result from increased public use after construction.

(2) Beneficial impacts. A total of 494 acres of undeveloped wildlife habitat would remain after construction of the NED Plan. Local assurances would be obtained to maintain the good to excellent quality wildlife habitat in its natural condition, with little disturbance other than a trail system.

(3) Net impacts. The 494 acres of undeveloped wildlife habitat remaining with the NED Plan would be more than twice the 241 acres that would remain under the "no project" alternative. A significant beneficial impact on the terrestrial ecosystem would result from the NED Plan.

b. EQ/Recommended Plan.

(1) Adverse impacts. Ninety-one acres of terrestrial wildlife habitat would be cleared to construct flood control structures, outdoor recreation facilities, and the 5 fish ponds. Wildlife communities would be disrupted by construction activities and increased public use.

(2) Beneficial impacts. A total of 4?5 acres of undeveloped wildlife habitat would remain after construction of the EQ recommended plan, nearly twice that projected for the "no project" alternative. Local assurances would be sought to preserve and maintain the good to excellent quality wildlife habitat, particularly lands at fish pond/detention sites, along stream reaches M2 to M5 in Bellefontaine County Park, and in the 4-acre bottomland hardwood forest in stream reach MD1-1 (a total of 414 acres). In addition, the wildlife habitat would be enhanced by the construction of the 5 fish ponds, providing a reliable year-round source of water to wildlife in these upland areas.

(3) Net impacts. A significant net beneficial impact on the terrestrial ecosystem would result from the EQ recommended plan.

205. Endangered or Threatened Species. No significant impact on endangered species would be expected from either the NED or EQ/recommended plans. An endangered species assessment is included in Appendix I.

206. Impacts on Cultural Elements. The cultural elements of noise, displacements, housing, leisure, cohesion, growth, health-safety-welfare, tax revenue, property values and land use shown in the following paragraphs.

207. Noise.

a. NED Plan.

(1) Adverse impacts. Short-term construction period noise levels will rise from a neighborhood average of 65 dBA's to 85 dBA's. This will be localized and periodic and depends upon the construction activity being experienced.

(2) Positive impacts. None.

(3) Net impacts. +20 dBA's short-term.

b. EQ/Recommended Plan.

(1) Adverse impacts. Same as NED Plan.

(2) Beneficial impacts. Same as NED Plan.

(3) Net impacts. Same as NED Plan.

208. Displacements.

a. NED Plan.

(1) Adverse impacts. There will be 74 homes displaced for construction, easements, rights-of-way, and flood damage reduction purposes.

(2) Beneficial impacts. Reduced annual flood damages.

(3) Net impact. +74 homes relocated.

b. EQ/Recommended Plan.

(1) Adverse impacts. Same as NED Plan.

(2) Beneficial impacts. Same as NED Plan.

(3) Net impact. Same as NED Plan.

209. Housing.

a. NED Plan.

(1) Adverse impacts. None.

(2) Beneficial impacts. A reduction in average annual damages to housing of $\pm$ 90 percent.

(3) Net impact. $\pm$90 percent reduction in annual damages.

b. EQ/Recommended Plan.

(1) Adverse impacts. None

(2) Beneficial impacts. A reduction in annual damages by about 90 percent and an increase in value of about $1,500 per structure.

(3) Net impact. About a 90 percent annual flood damage reduction.

210. Leisure.

a. NED Plan.

(1) Adverse impacts. None.

(2) Beneficial impacts. The NED plan will generate nearly 273,000 user days of recreation annually.

(3) Net impact. 273,000 user days of recreation.

b. EQ/Recommended Plan.

(1) Adverse impacts. None

(2) Positive impacts. Same as NED Plan.

(3) Net impact. Same as NED Plan.

211. Cohesion.

a. NED Plan.

(1) Adverse impacts. None.

(2) Beneficial impacts. Community cohesion will be improved due to 90 percent annual damage reduction from flooding.

(3) Net impact. Community cohesion improved.

b. EQ/Recommended Plan

(1) Adverse impacts. None.

(2) Beneficial impacts. Same as NED Plan.

(3) Net impact. Same as NED Plan.

212. Growth

a. NED Plan.

(1) Adverse impacts. None.

(2) Beneficial impacts. The NED Plan will generate 1,533 man-years of employment and business activity of $77,200,000.

(3) Net impact. Improved regional growth.

b. EQ/Recommended Plan.

(1) Adverse impacts. None.

(2) Beneficial impacts. Same as the NED Plan.

(3) Net Impact. Same as the NED Plan.

213. Health, Safety and Welfare.

a. NED Plan.

(1) Adverse impacts. None.

(2) Beneficial impacts. Greatly improved damage reduction. This includes a damage reduction of 90 percent and a 50 percent decline in damages at the 100-year flood event.

(3) Net impact. Greatly reduced flood damages.

b. EQ/Recommended Plan.

(1) Adverse impacts. None.

(2) Beneficial impacts. Greatly improved damage reduction. This includes a damage reduction of about 90 percent and a 52 percent decline in damages at the 100-year flood event.

(3) Net impact. Same as NED Plan.

214. Tax Revenue.

a. NED Plan.

(1) Adverse impacts. None.

(2) Beneficial impacts. Increased tax revenue of $770,000 during construction.

(3) Net impact. $770,000 tax revenue.

b. EQ/Recommended Plan.

(1) Adverse impacts. None.

(2) Beneficial impacts. Same as NED Plan.

(3) Net impact. $770,000 increased tax revenue.

215. Property Values.

a. NED Plan.

(1) Adverse impacts. None.

(2) Beneficial impacts. Increase housing values on an average of $1,500 to homes located in the protected flood plain.

(3) Net impact. $1,500 increase vaue overall.

b. EQ/Recommended Plan.

(1) Adverse impacts. None.

(2) Beneficial impacts. Same as NED Plan.

(3) Net impact. $1,500 increase value overall.

216. Land Use.

a. NED Plan.

(1) Adverse impacts. None.

(2) Beneficial impacts. Plan is in agreement with St. Louis County's "General Plan."

(3) Net impact. Full coordination with local land use plans.

b. EQ/Recommended Plan.

(1) Adverse impacts. Same as NED Plan

(2) Beneficial impacts. Same as NED Plan

(3) Net impact. Same as NED Plan.

217. Archaeological and Historic Sites. One site on the National Register of Historic Places, the Bissel House, is located in the watershed, but not in the project area. No impacts on historic sites would be expected from either the NED or EQ/recommended plan. No significant archaeological resources were identified in the project area during the cultural resources survey. However, this does not preclude the possibility that deeply buried archaeological sites may be present. These sites could conceivable be uncovered during construction activities of either the NED or EQ/recommended plan. Therefore, all subsurface excavations created during construction would be closely monitored by a qualified archaeologist.

Mitigation Requirements

218. The potential need for mitigation of wildlife habitat destruction caused by the NED and EQ/recommended plans was evaluated by developing TABLE B-45. First, the existing undeveloped wildlife habitat on project rights-of-way was determined. Then, the projected acreage of wildlife habitat with the "no project" and NED and EQ/Recommended alternative plans was determined. Both the NED and EQ/Recommended alternatives exceed the no project alternative by

close to two-fold values. Under both the NED and EQ/Recommended alternatives, development of project lands would be minimal with an emphasis on nature trails and similar outdoor recreation pursuits. Assurances would be sought from the local sponsors to preserve most of the habitat in its natural state. The conclusion from this analysis is that no wildlife habitat mitigation would be required for either the NED or EQ/Recommended alternative plans.

219. The need for aquatic habitat mitigation was also considered. No mitigation would be necessary for the EQ/Recommended plan, inasmuch as the plan includes both fish ponds and instream aquatic habitat structures to enhance the aquatic habitat. Some mitigation might be necessary for the NED Plan were it implemented, because of the channel straightening in stream reaches M5, M6, and MD1. The possibility of either attempting to preserve the cutoff reaches of stream in some aquatic habitat form or of including aquatic habitat structures in the improved reaches were both given preliminary consideration. Neither alternative would be of sufficient cost to affect the final plan selection.

220. The EQ/Recommended plan of improvements was selected on the basis of an unbiased analysis of the full range of all relevant alternative means to achieve proposed project objectives and purposes singlely or in combination reflecting different choice criteria. This assessment included the full range of structural and nonstructural alternatives analyzed to resolve the water and related land use problems, while protecting, preserving, and enhancing the quality of the environment and restoring environmental quality previously lost. At each stage of analysis, all relevant alternatives were studied and screened on an equal level of detail in order to preclude any technical bias in the analysis.

TABLE B-45
MALINE CREEK
MITIGATION ANALYSIS
(The EQ Plan is the Recommended Plan)

Site	Project Acreage (A)	Current Undevel. Project Acreage	Projected Future Clearing: No Project (B)	Projected Future Clearing: NED Plan (C)	Projected Future Clearing: EQ Plan (D)	Net Acres Undeveloped Wildlife Habitat: No Project	Net Acres Undeveloped Wildlife Habitat: NED Plan	Net Acres Undeveloped Wildlife Habitat: EQ Plan
Detention Site								
MP2	14	14	14	0	0	0	14	14
MD1	20	0	0	0	0	0	0	0
MD1-1	73	73	60	8	10	13	65	63
MD2-2	41	41	31	6	10	10	35	31
MF1	35	35	0	5	5	35	30	30
MF2	6	0	0	0	0	0	0	0
MH1	70	70	70	12	14	0	58	56
M22	61	61	61	6	8	0	55	53
M27	64	64	64	11	15	0	53	49
Stream Corridor								
M1	18	6	6	4	4	0	2	2
M2	61	61	0	1	1	61	60	60
M3	18	18	0	1	1	18	17	17
M4	26	26	0	1	1	26	25	25
M5	59	59	0	5	5	59	54	54
M6	29	0	0	0	0	0	0	0
M7	24	0	0	0	0	0	0	0
M8	13	0	0	0	0	0	0	0
M9	47	10	0	4	7	10	6	3
M10	19	4	4	2	3	0	2	1
M11	6	0	0	0	0	0	0	0
M12	9	0	0	0	0	0	0	0
M13	16	4	4	2	2	0	2	2
M14	19	4	4	2	2	0	2	2
M15	12	0	0	0	0	0	0	0
M16	12	0	0	0	0	0	0	0
MB	3	0	0	0	0	0	0	0

TABLE B-45 (Continued)
MALINE CREEK
MITIGATION ANALYSIS
(The EQ Plan is the Recommended Plan)

Site	Project Acreage (A)	Current Undevel. Project Acreage	Projected Future Clearing			Net Acres Undeveloped Wildlife Habitat		
			No Project (B)	NED Plan (C)	EQ Plan (D)	No Project	NED Plan	EQ Plan
MD1	18	9	0	1	1	9	8	8
MD2	17	9	0	0	0	0	0	0
MD3	6	0	0	0	0	0	0	0
MD4	6	0	0	0	0	0	0	0
MD5	4	0	0	0	0	0	0	0
MD1-1	14	8	8	2	2	0	6	6
MD1-2	8	0	0	0	0	0	0	0
MH	10	0	0	0	0	0	0	0
Subtotal:								
Detention	384	358	300	48	62	58	310	296
Stream	474	209	26	25	29	183	184	180
Grand Total	858	567	326	73	91	241	494	476

A. This includes 567a for flood control plus 291a for EQ/Recreation.

B. It is assumed that all of the lands in private ownerhsip will be developed in the future without a project. Publicly owned lands will remain undeveloped.

C. The differences in clearing required for the NED and EQ plans are two-fold: (1) The NED Plan requires no clearing for fish ponds; (2) The NED Plan requires no clearing for channel improvements in stream reaches M8 and M10.

D. This is a maximum value as it not only includes the complete clearing required for construction, but it includes selective clearing (brush-hogging of the understory, leaving the overstory trees).

RECOMMENDED PLAN

221. The EQ plan was designated for recommendation as a result of the many sequential screenings previously described. Additional details of the various features of the recommended plan of improvements are summarized in APPENDIXES D, E and F.

Implementation Responsibilities

222. States and local governments have more immediate and utilitarian interest in water resource management. Their well-being, as that of the Nation as a whole, depends upon the availability of water resources of adequate quality and quantity. Acts of Congress, and interpretations thereof by the Supreme Court, clearly indicate that the Federal Government may participate to some degree in all aspects of water and related land conservation, development, and management. However, the degree of Federal participation and financing is generally limited to that required to achieve national objectives in an optimal manner. Federal participation for local flood protection projects varies from a maximum for sound planning to less for construction, and to still less for operation and maintenance activities.

Cost Apportionment

223. Apportionment of project costs is understood and used to mean the division or sharing of project costs among the various users, interests and agencies that will pay for the project. The cost allocated to specific project purposes are shared generally in accordance with pertinent Federal laws and the traditional agency principles and policies. For pre-authorization studies, such as Maline Creek, a letter of intent to participate must be received from the Governor of Missouri, and/or from a properly authorized

non-Federal public agency (such as the St. Louis Metropolitan Sewer District), stating their ability and willingness to cooperate. In accordance with law, authorizations for local flood protection projects such as Maline Creek expire, if satisfactory assurance of cooperation are not provided from responsible non-Federal entities, within 5 years after being requested by the District Engineer. The amount of the local (non-Federal) cooperation required, both monetary and non-monetary, is dependent upon the nature of the project under consideration and the general and specific laws pertinent thereto.

224. In his 6 June 1978 message to Congress on Water Policy, President Carter proposed cost-sharing reforms which impact on the Corps' civil works program, and specifically on the Maline Creek cost sharing. Effective 9 April 1979 the Corps of Engineers will recommend that Congress authorize the selected plan of improvements in accordance with the President's proposed cost-sharing policies. Until new legislation is enacted, the estimates of Federal and non-Federal interests costs will be identified under both existing legislation as well as the President's proposed cost-sharing policies. The differences in cost-sharing in no way change the level of development and/or the plan formulation process leading to the recommended plan of improvements under the Corps' planning process. The Corps' criteria for recommending Federal (Corps) participation in a plan of improvements remains the net benefit rule and the Corps' authority to implement the plan. Both cost sharing apportionments are shown in the following paragraphs.

Traditional Cost Apportionment

225. The traditional Federal (Corps) cost apportionment is based on sections a, b and c of the Flood Control Act of 1936, as amended, for cost allocated to the flood control purpose. In summary, the

traditional cost apportionment is as follows: "section a (FCA36) requires that the local non-Federal sponsor be required to provide all lands, easements, rights-of-way and relocations; b. section b (FCA36) requires that the local sponsor hold and save the Government free of any claims resulting from project installation; c. section c (FCA36) requires that the local sponsor operate and monitor the completed project in accordance with rules prescribed by the Secretary of the Army; d. outdoor recreational costs be shared 50/50 based on section 73, Public Law 93-251; e. environmental enhancement costs be shared 75/25 (Federal/non-Federal) based on Public Law 93-251. TABLE B-46 shows a summary of the "traditional" apportionment of construction costs. The detailed cost estimate is presented in the design and cost discussion, APPENDIX E.

TABLE B-46
MALINE CREEK
TRADITIONAL CONSTRUCTION COST APPORTIONMENT

ITEM	FEDERAL	NON-FEDERAL	TOTAL
01. LANDS AND DAMAGES	$ 840,000	$ 10,300,000	$ 11,140,000
Nonstructural Flood Control			
Structural Flood Control			
Recreation, Fish and Wildlife			
02. RELOCATIONS	0	2,720,000	2,720,000
04. DAMS	6,170,000	0	6,170,000
06. FISH AND WILDLIFE	880,000	290,000	1,170,000
09. CHANNELS AND CANALS	5,570,000	0	5,570,000
11. LEVEES AND FLOODWALLS	8,850,000	0	8,850,000
14. RECREATION	1,400,000	1,400,000	2,800,000
30. ENGINEERING AND DESIGN	2,750,000	580,000	3,330,000
31. SUPERVISION AND ADMINISTRATION	1,680,000	370,000	2,050,000
TOTAL CONSTRUCTION COSTS	$ 28,140,000	$ 15,660,000	$ 43,800,000

226. The apportionment of annual operation and maintenance costs based on traditional cost sharing is as shown in TABLE B-47. The cost sharing for the operation and maintenance annual costs remains the same under the President's proposed cost sharing apportionment.

TABLE B-47
MALINE CREEK
TRADITIONAL O&M COST APPORTIONMENT SAME AS
PRESIDENT CARTER'S O&M COST APPROTIONMENT

ITEM	FEDERAL	NON-FEDERAL	TOTAL
Flood Control Requirements	$ 0	$ 305,600	$ 305,600
Environmental Quality Requirements	0	41,800	41,800
Recreation Requirements	0	102,600	102,600
TOTAL O&M COSTS	$ 0	$ 450,000	$ 450,000

Recommended Cost Apportionment

227. The President has proposed that the present cost-sharing requirements for the flood damage prevention portion of projects (as previously identified for Maline Creek), be modified to require a cash or in-kind contribution equal to 20 percent of the first costs of construction assigned to the flood damage prevention project purpose. In addition, the State in which the project is located must provide cash or in-kind contributions equal to 5 percent of the first costs of construction assigned to the flood damage prevention project purpose. The Maline Creek recommended cost apportionment based on President Carter's proposed cost sharing is summarized in TABLE B-48. The detailed cost estimate is provided in design APPENDIX E.

TABLE B-48
MALINE CREEK
PRESIDENT CARTER'S PROPOSED CONSTRUCTION COST APPORTIONMENT

ITEM	STATE COST	NON-FED COST	FED COST	TOTAL COST
Flood Control	1,890,000	7,550,000	28,300,000	37,740,000
Recreation	230,000	2,330,000	2,100,000	4,660,000
Environmental Quality	70,000	700,000	630,000	1,400,000
TOTAL CONSTRUCTION COSTS	$2,190,000	$10,580,000	$31,030,000	$43,800,000

228. President Carter's cost-sharing proposal makes no changes in the apportionment of annual operation and maintenance requirements. The entire O&M cost is a responsibility of non-Federal interests, which amounts to $450,000 annually for Maline Creek.

PUBLIC VIEWS

Views of Federal Agencies

229. The views and comments of all known interested federal agencies have been actively solicited from study inception. The cooperation, assistance and participation of the Bureau of Outdoor Recreation (now called the Heritage Conservation and Recreation Service), the Environmental Protection Agency and the United States Geological Service was particularly beneficial to study success and is sincerely appreciated. Similar to earlier study report processing, the draft final Maline Creek survey report was furnished to all federal water resource agencies, regardless of their previously expressed interest or lack of interest. The text of the responses received from federal agencies is reproduced verbatim, along with an item by item Corps response, in Appendix C. The federal agency review comments are rather complimentary of the Corps planning effort and proposed solution.

Views of Non-Federal Agencies

230. Similar to the federal agency coordination, every effort has been made to actively involve all known interested water and related land resouce non-federal agencies. The list of non-federal agencies solicited for views and their responses are reproduced in Appendix C.

MALINE CREEK, MISSOURI

SURVEY REPORT FOR FLOOD CONTROL
AND ALLIED PURPOSES

APPENDIX C

PUBLIC VIEWS AND RESPONSES

The appendix contains comments received on the Maline Creek Draft Survey Report and Environmental Impact Statement. The three volumes of this report were furnished to over 150 residents in the Maline Creek area and to the following agencies, organizations, and officials for review and comment:

- U.S. House of Representatives (6 copies)
  - Honorable William Clay
  - Honorable Robert A. Young
  - Honorable Harold L. Volkmer
- U. S. Senate (4 copies)
  - Honorable John C. Danforth
  - Honorable Thomas F. Eagleton
- U.S. Coast Guard (2 copies)
- U.S. Department of Agriculture
  - Forest Service (3 copies)
  - Soil Conservation Service (5 copies)
- U.S. Department of Commerce (1 copy)
  - National Weather Forecast Office (2 copies)
- U.S. Department of Energy (1 copy)
- U.S. Department of Health, Education, and Welfare (1 copy)
- U.S. Department of Housing and Urban Development (2 copies)
- U.S. Department of the Interior
  - Office of Environmental Project Review (20 copies)
  - Fish and Wildlife Service (1 copy)
  - Geological Service (1 copy)
  - Heritage, Conservation and Recreation Service, Advisory Council on Historic Preservation (1 copy)
- U.S. Department of Transportation (2 copies)
- U.S. Environmental Protection Agency (3 copies), Denver Regional Office
- U.S. Environmental Protection Agency (3 copies) Washington, D.C.
- Federal Emergency Management Agency (2 copies)

State of Missouri, Executive Branch

- Governor Joseph Teasdale (1 copy)
- State Office of Administration, Division of Budget and Planning (15 copies)
- State Conservation Commissioners
  - W. Robert Aylward (1 copy)
  - J. Ernest Dunn, Jr. (1 copy)
  - Jack Waller (1 copy)
  - Carl Disolvo (1 copy)
- Department of Conservation (3 copies)
- Department of Natural Resources (3 copies)
- State Highway Department (1 copy)

Missouri State Legislators

- Honorable Francis Brady, Jr. (1 copy)
- Honorable Fred B. Brummel (1 copy)
- Honorable Edwin L. Dirck (1 copy)
- Honorable Bob Feigenbaum (1 copy)
- Honorable Robert Fowler (1 copy)
- Honorable Joe Frappier (1 copy)
- Honorable Wayne Goode (1 copy)
- Honorable Francis Markwell (1 copy)
- Honorable Carl H. Muckler (1 copy)
- Honorable Allan G. Mueller (1 copy)
- Honorable Earl L. Schlef (1 copy)
- Honorable John D. Schneider (1 copy)
- Honorable Harriet Woods (1 copy)

St. Louis County

- County Executive Gene McNary (1 copy)
- Department of Planning (2 copies)
- Department of Highways and Traffic (1 copy)
- Department of Parks and Recreation (3 copies)
- Department of Public Works (2 copies)
- Office of Civil Preparedness (1 copy)

AD-A140 671 WATER RESOURCES INVESTIGATION ST LOUIS METROPOLITAN AREA MISSOURI AND ILL..(U) ARMY ENGINEER DISTRICT ST LOUIS MO SEP 80 5/7

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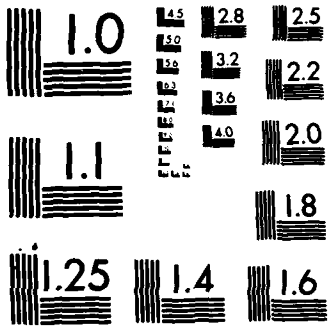


MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

City of St. Louis

- Mayor James Conway (1 copy)
- Department of Parks and Recreation (1 copy)
- Director of Disaster Preparedness (1 copy)
- Community Development Agency (1 copy)

Mayors (22 copies)

Bellefontaine Neighbors	Florissant
Bellerive	Jennings
Bel-Nor	Kinloch
Bel Ridge	Moline Acres
Berkeley	Normandy
Black Jack	Overland
Calverton Park	Pasadena Park
Charlack	Riverview
Cool Valley	St. John
Dellwood	Sycamore Hills
Ferguson	Vinita Park

American Planning Association, St. Louis Section (2 copies)

East-West Gateway Coordinating Council (3 copies)

Bi-State Development Agency (1 copy)

Metropolitan St. Louis Sewer District (5 copies)

American Fisheries Society, Missouri Chapter (1 copy)

Audubon Society

- National Audubon Society (1 copy)
- Audubon Society of Missouri (1 copy)

Bi-State Stormwater Committee, Missouri and Illinois

- Henry Reitz (1 copy)
- Luis Zambrana (1 copy)
- John Bogdanor (1 copy)
- George Hasegawa (1 copy)
- Mike Keefe (1 copy)
- James Schoonover (1 copy)
- Jack Enger (1 copy)
- Stifel Jens (1 copy)
- Debra Miller (1 copy)

Coalition for the Environment (St. Louis) (3 copies)
Conservation Federation of Missouri (1 copy)
Izaak Walton League, St. Louis Chapter (1 copy)
Missouri Archaeological Survey (1 copy)
Missouri Botanical Garden (1 copy)
Sierra Club, Ozark Chapter (1 copy)
The Wildlife Society, Missouri Chapter (1 copy)
Webster Groves Nature Study Society (1 copy)
Black and Veatch Consulting Engineers (2 copies)
Sverdrup and Parcel and Associates (2 copies)
John Lark and Associates (1 copy)
Stuart M. Mertz and Associates (1 copy)
Reitz and Jens, Inc. (2 copies)
Southern Illinois University at Edwardsville, Office of Research and Projects (1 copy)
Washington University, Tyson Research Center (1 copy)

The covering letter transmitting the draft report stated that it would be assumed that no response meant the reviewer concurred with the draft report. Comments received and attached in this appendix are from the following:

U.S. Fish and Wildlife Service
U.S. Department of Housing and Urban Development
U.S. Heritage Conservation and Recreation Service
U.S. Bureau of Mines
Missouri Department of Natural Resources
Missouri Department of Conservation
St. Louis County Department of Parks and Recreation
Metropolitan St. Louis Sewer District
City of Jennings
American Fisheries Society
Reitz & Jens, Inc.

Letters and notes of telephone calls from residents of the Maline Creek watershed are on file with the St. Louis District, Corps of Engineers. These inquiries were primarily concerned with the effects of the selected plan on the individual's property. The individuals were contacted by the Corps of Engineers and their questions answered.

United States Department of the Interior
FISH AND WILDLIFE SERVICE
2701 Rockcreek Parkway, Suite 106
North Kansas City, Missouri 64116

KANSAS CITY AREA OFFICE
816/374-6166

ECOLOGICAL SERVICES
816/374-5951

August 8, 1980

Mr. Jack R. Niemi
Chief, Engineering Division
Office of the District Engineer
210 Tucker Boulevard, North
St. Louis, Missouri 63101

Dear Mr. Niemi:

In response to a memorandum dated July 15, 1980, from the Director of Environmental Project Review, we have reviewed the Draft Environmental Impact Statement and Survey Report for the Maline Creek, Missouri flood control study, and offer the following comments for your consideration.

Our review indicates that there are no lands involved which were acquired with Federal grant-in-aid assistance under the Wildlife Restoration Act (Pittman-Robertson Act - Public Law 75-415) or the Fish Restoration Act (Dingell-Johnson Act - Public Law 81-681).

We were pleased with the sensitivity to environmental and recreational needs shown in the Survey Report. Multiple use features, the hallmark of this project, should prove to be valuable assets to the communities involved. Aquatic and riparian habitat preservation and enhancement have been made important project objectives. The additional emphasis on recreational elements, such as fishing ponds and nature trails, nicely rounds out the project's scope.

The Survey Report was very thorough and adequately addressed all facets of the project that are of interest to the Fish and Wildlife Service. We look forward to the timely implementation of this worthy project. Thank you for allowing us extra time to complete our review of the study.

Sincerely,

for Tom A. Saunders
Area Manager

cc: RD, Denver, CO (ENV/LWRDP)
Director, Fish & Wildlife Service
Washington, DC (FWS/OEC)
OEPR, Washington, DC

COMMENT RESPONSE SHEET

U.S. Fish and Wildlife Service letter dated 8 August 1980.

Reference paragraph number:

1. No response needed.

2. Comment noted.

3. Comment noted. The coordination and assistance of the Fish and Wildlife Service relative to this aspect of our study efforts is appreciated.

4. Comment noted.

U.S. Department of Housing and Urban Development
REGION VII

In Reply Refer to:

St Louis Area Office
210 North Tucker
St Louis, Missouri 63101

July 28, 1980

Mr. Jack Niemi
Chief
Engineering Division
St. Louis District Corps of Engineers
210 North Tucker Boulevard
St. Louis, Missouri 63101

Dear Mr. Niemi:

I have reviewed the three volume draft Survey Report and find that it presents a most equitable and promising proposal for Maline Creek. In no way do I find the selected Environmental Quality Plan myopic. The study considers and evaluates all reasonable alternatives and the solutions are most complete. Retroactive planning and drainage reclamation for an urban area is infinitely challenging but a resourceful and masterful plan has been unfolded.

The Study does not waltz around the issues and it is a true breakthrough for correcting and reducing flood hazards as well as reclaiming the potentials of an urban drainage system where some reaches epitomize total and absolute indifference of man to nature.

One of the unique features of the plan is its physiographic linkage. The proposal will actually serve as one of the primary connectors to the Mississippi, Meramec, and Missouri River Environmental Circular Corridor which presently serves the St. Louis Metropolitan area.

By all means this planned proposal should be implemented as swiftly as possible. However, top priority should always be given to the business of preventing people from making a needless flood hazard in the first place. The theme for the Environmental Quality Plan should be that flood and bank erosion disasters along Maline Creek are "not natural" and that we cannot correct the so-called imperfections of nature. Regretfully in many areas we spend endless millions of dollars to encourage development while we spend other millions to encourage the protection of the floodplain. When nature proves us fools by flooding and destroying what we have built , we start all over again because generally we have insured what was bound to be destroyed.

Your outlined proposals eliminates most of the past errors along Maline Creek by successfully incorporating a consciousness of the environment particularly in those blighted and barren areas where respectibility must be restored to the landscape. I would like to emphasize that the importance of the stream-side landscape should never be disprized. Sensitive architectural and landscaping designes will produce some aesthetically interesting stream-side patterns along Maline Creek.

In an era of urban and neighborhood re-discovery the EQ Plan brings parks and recreation to where the people are. The fact that some type of outdoor recreation opportunity could be less then fifteen minutes from most of the people who reside in this watershed adds to the plan's unique value. Many of the residents in the Maline Creek watershed, buffeted by inflation and energy shortages, are now shifting their leisure time and recreation closer to home. Some are discovering their local parks that have always been there and didn't realize they could enjoy them. For the most part the existing park systems are having a desperate time meeting the demands. Visits to St. Louis County Parks (1979) have jumped 50 to 75 percent or even higher.

It should be noted that the need for new parks, especially in the Maline Creek area, is greater then ever. It is in these mature suburban areas of St. Louis County where more then seventy percent of the new-recreation capacity needs are located.

Traditionally the parks in St. Louis County were selected on the elitist principal of saving the best. Now greater effort must be made to save some of the remaining vacant lands while they are still there. To expect the incorporated communities to meet this demand alone is to expect the impossible and to abrogate the federal responsibilities.

Hopefully there will be no public or private actions which will be so short-sighted as to allow other matters to undercut the thrust for environmental protection, flood control and recreation along Maline Creek. As reflected in your Survey Report, it is not a question of sacrificing all other concerns to the proper management of Maline Creek but of achieving a balance in which there is no place for continued short-sighted neglect. If implementation of the proposals is posponed irresponsible exploitation will extend and the drainage system will continue to be grossly neglected and eroded. It would be most tragic if the plan proposals are shunted aside, just as our metropolitan area enters a challenging new stage in the interest of resource affairs.

The proposed Environmental Quality Plan is most appropriate and should indeed fire the imagination and support of a broad range of agencies, organizations, and communities. At an opportune hour it presents a historic and corrective environmental challenge to a highly urbanized portion of St. Louis County.

Last but not least the suggested proposals not only emulate good land use planning, but are super economics. The residents are now the key participants in the outcome.

Thank you for the opportunity to comment on this survey report, and we look forward to receiving a copy of your final statement when it becomes available.

Sincerely,

Walter L. Eschbach

Walter L. Eschbach
Environmental Officer

COMMENT RESPONSE SHEET

U.S. Department of Housing and Urban Development letter dated 28 July 1980.

Reference paragraph number:

1. No response required.

2. No response required.

3. No response required.

4. No response required.

5. No response required.

6. No response required.

7. No response required.

8. No response required.

9. Concur.

10. No response required.

11. No response required.

United States Department of the Interior
HERITAGE CONSERVATION AND RECREATION SERVICE
MID-CONTINENT REGION
POST OFFICE BOX [illegible]
DENVER FEDERAL CENTER
DENVER COLORADO [illegible]

IN REPLY REFER TO:

AUG 8 1980

Jack R. Niemi, Chief
Engineering Division
Office of the District Engineer
St. Louis District
Corps of Engineers
210 Tucker Boulevard North
St. Louis, MO 63101

Dear Mr. Niemi:

The Mid-Continent Region, Heritage Conservation and Recreation Service, has reviewed the Maline Creek, Missouri, survey report and offer the following comments.

As you know, this office has participated in the development of the recreation portion of this study. We believe our early involvement in this effort has a considerable amount of merit in that an excellent cooperating relationship has developed between the district and our office.

The selected EQ plan has a number of interesting and innovative approaches, such as the utilization of the abandoned railroad, the recommended fish ponds, and the backyard wildlife habitat areas. We believe this report has recommended the best possible alternative and highly commend your staff for their fine efforts. The implementation of the Maline Creek project could well be an example for other cities to emulate and we envision a remarkable asset to the various communities for open space and park uses.

We, therefore, fully support the Maline Creek survey report because of our interest in urban waterfront revitalization efforts and offer our assistance in the project's future implementation.

Sincerely,

Albert G. Baldwin
Assistant Regional Director
Resource Planning Services

COMMENT RESPONSE SHEET

U.S. Heritage Conservation and Recreation Service letter dated 8 August 1980.

Reference paragraph number:

1. No response required.

2. Concur.

3. No. response required.

4. The Corps of Engineers will coordinate with HCRS during the implementation phase of the plan.

United States Department of the Interior
BUREAU OF MINES
P. O. BOX 25086
BUILDING 20, DENVER FEDERAL CENTER
DENVER, COLORADO 80225
Intermountain Field Operations Center

July 31, 1980

Mr. Jack R. Niemi
Chief, Engineering Division
Department of the Army
St. Louis District Corps of Engineers
210 Tucker Boulevard, North
St. Louis, Missouri 63101

Dear Mr. Niemi:

The draft report for Water Resources Investigation, Maline Creek, St. Louis County, Missouri (ER 80/725), has been reviewed by Bureau of Mines personnel. As described in the executive summary, "The 25 square mile study area is located from the Lambert St. Louis International Airport, eastward through urbanized St. Louis County and the city of St. Louis, Missouri, to the Mississippi River. The object of this study is to identify comprehensively all alternative options and to recommend a solution to the problems normally associated with urban stormwater sewers such as: flooding; streambank erosion; lack of outdoor recreation; and, environmental degradation."

Our concern essentially is limited to the impacts that the proposed project would have on mineral resources and mining industries in the study area, and the adequacy of the report in dealing with those subjects. The existence in the study area of commercially valuable limestone and shale deposits used by the Missouri Portland Cement Co. is acknowledged in the report. Oil and gas production is discussed, and the thin, irregular coalbeds that are present in the region also are mentioned. But, as was stipulated in a previous memorandum from the Bureau of Mines (October 31, 1973), and as implied in the draft report in a paragraph on oil and gas, urbanization will have a greater adverse impact on mineral production and processing than the project. Controlling storm runoff should be as beneficial to the minerals industry as to other interests.

Sincerely yours,

Jimmie E. Jinks
Acting Chief, IFOC

COMMENT RESPONSE SHEET

U.S. Bureau of Mines letter dated 31 July 1980.

Reference paragraph number:

1. No response required.

2. Concur.

MISSOURI DEPARTMENT OF NATURAL RESOURCES
P.O. Box 176 Jefferson City, Missouri 65102 (314) 751-4422

August 1, 1980

Colonel Robert J. Dacey
District Engineer
St. Louis District, Corps of Engineers
210 Tucker Boulevard, N.
St. Louis, Missouri 63101

Dear Colonel Dacey:

The Department of Natural Resources has reviewed the Maline Creek Draft Survey Report. We concur with the recommendation that environmental quality plan 78.2 be selected. Any money required of the state as part of this project would, of course, have to be appropriated by the state legislature.

Thank you for the opportunity to comment on this report.

Sincerely,

DEPARTMENT OF NATURAL RESOURCES

Fred A. Lafser
Director

FAL:rjk

Joseph P. Teasdale Governor
Fred A. Lafser Director

COMMENT RESPONSE SHEET

Missouri Department of Natural Resources letter dated 1 August 1980.

Reference paragraph number:

1. The St. Louis District, Corps of Engineers, contacted the Missouri Department of Natural Resources (Mr. Dunkenson) by telephone on 20 August 1980 regarding a letter of assurance from the state of Missouri. Mr. Dunkenson indicated that the state believes the Department of Natural Resources response is all the Corps requires at this time. Page 68 of the Maline Creek Main Report indicates that the Chief of Engineers will ask for comment from the Governor of Missouri after the Lower Mississippi Valley Division, the Board of Engineers for Rivers and Harbors, and the Office, Chief of Engineers have reviewed the report. If the report is not significantly modified during this review process, the Governor will provide the required letter of assurance. The St. Louis District agrees with the logic of this approach.

2. No response required.

MISSOURI DEPARTMENT OF CONSERVATION

MAILING ADDRESS:
P.O. Box 180
Jefferson City, Missouri 65102

STREET LOCATION:
2901 North Ten Mile Drive
Jefferson City, Missouri 65101

Telephone 314 751-4115
LARRY R. GALE, Director

July 30, 1980

Colonel Robert J. Dacey
District Engineer
U. S. Army Engineer District
St. Louis Corps of Engineers
210 North Tucker
St. Louis, Missouri 63101

Re: LMSED-BU

Dear Colonel Dacey:

The opportunity to review the Maline Creek Draft Survey Report dated June 1980 is appreciated. Members of my staff involved in the review indicate the report is thorough and proves an excellent balance for urban resource development. We are pleased that the report includes development of riparian and aquatic habitat, an extremely valuable entity in the urban setting. As the project unfolds, we would investigate the contribution of the selected plan to urban fishing and determine our level of participation in this project.

In the next few weeks, we will complete a detailed review of the proposed fish habitat structures and other features. Hopefully comments will be accepted at that time.

Once again, the opportunity to review this excellent draft is appreciated.

Sincerely,

Larry Gale

LARRY R. GALE
DIRECTOR

cc: U. S. Fish and Wildlife Service
Kansas City, Missouri

COMMENT RESPONSE SHEET

Missouri Department of Conservation letter dated 30 July 1980.

Reference paragraph number:

1. The Corps of Engineers will coordinate with the Department of Conservation during the final planning phases to determine possible Department of Conservation participation in urban fishing and other aspects of the project.

2. The St. Louis District is very interested in receiving input from the Missouri Department of Conservation on this project. Comments are welcome at any time, however, they may not be published if received after printing date. The comment, however, will still receive full consideration in our efforts to propose the best possible solution.

3. No response required.

ST. LOUIS COUNTY, MISSOURI
GENE McNARY, COUNTY EXECUTIVE
DEPARTMENT OF PARKS AND RECREATION
WAYNE C. KENNEDY, DIRECTOR

August 28, 1980

Colonel Robert J. Dacey
Department of the Army
St. Louis District, Corps of Engineers
210 Tucker Boulevard, North
St. Louis, Missouri 63101

Dear Colonel Dacey:

Re: Maline Creek Survey Report

St. Louis County Department of Parks & Recreation has reviewed the Maline Creek Survey Report, and would like to go on record approving, in concept, this study.

It should be pointed out that the St. Louis County Department of Parks and Recreation has prepared a study on Linear Parks along Maline Creek, as well as three other major watershed areas in the County. While we are in full support of the linear park and recreation concept, we would like to state that our agency would be extremely hesitant to accept the financial responsibility of maintaining such an area at this time.

Sincerely yours,

Wayne C. Kennedy

Wayne C. Kennedy
Director

WCK/APB/fw

cc: Albert L. Phillips
Armand P. Brunet

41 SOUTH CENTRAL AVENUE, CLAYTON, MISSOURI 63105 (314) 889-3208

COMMENT RESPONSE SHEET

St. Louis County Department of Parks and Recreation letter dated 28 August 1980.

Reference paragrpah number:

1. No response required.

2. Comment noted. The St. Louis District has a copy of the Linear Park Project report.

METROPOLITAN ST. LOUIS SEWER DISTRICT

MSD

July 11, 1980

Colonel Robert J. Dacey
U. S. Army Corps of Engineers
210 North 12th Street
St. Louis, Missouri 63101

Dear Colonel Dacey:

The Metropolitan St. Louis Sewer District concurs in general with your June, 1980 draft of the recommended Maline Creek plan of improvements. Although the previous proposals were more thorough and extensive, the cost was beyond the capability of the residents in the watershed. The recent proposal appears to be more in line with what the people can afford.

The Metropolitan St. Louis Sewer District will be very happy to act as the local sponsor for this proposed project and will seek participation from the state of Missouri, St. Louis County and the various municipalities in the project area.

Thank you very much for your continued cooperation in urban flood control projects.

Sincerely,

Robert S. Flick

Robert S. Flick
Executive Director

RSF/js

2000 HAMPTON AVENUE • ST. LOUIS, MISSOURI 63139 • 768-6200

COMMENT RESPONSE SHEET

Metropolitan St. Louis Sewer District letter dated 11 July 1980.

Reference paragraph number:

1. No response required.

2. The Corps of Engineers appreciates the Metropolitan St. Louis Sewer District's committment to act as local sponsor for the Maline Creek project. We believe the MSD has the necessary legal and financial resources to act as local sponsor for Maline Creek proposed improvements.

3. No response required.

METROPOLITAN ST. LOUIS SEWER DISTRICT

MSD

July 23, 1980

Mr. Arthur L. Johnson
Acting Chief, Engineering Division
Department of the Army
St. Louis District, Corps of Engineers
210 Tucker Boulevard, North
St. Louis, Missouri 63101

Dear Mr. Johnson:

Copies of your letter have been forwarded to Mr. John Koeper, Director of Maintenance, and Mr. Chuck Etwert, Director of Engineering for their review and comments.

I am also enclosing a copy of my letter to Colonel Dacey which indicates the District's intent to act as a local sponser for the Maline Creek Project.

If we can be of any further assistance please let me know.

Sincerely,

Robert S. Flick

Robert S. Flick
Executive Director

RSF/jms

cc: Messrs. Kaiser, Enger, Etwert, Koeper

2000 HAMPTON AVENUE • ST. LOUIS, MISSOURI 63139 • 768-6200

COMMENT RESPONSE SHEET

Metropolitan St. Louis Sewer District letter dated 23 July 1980.

Reference paragraph number:

1. No response required.

2. No response required.

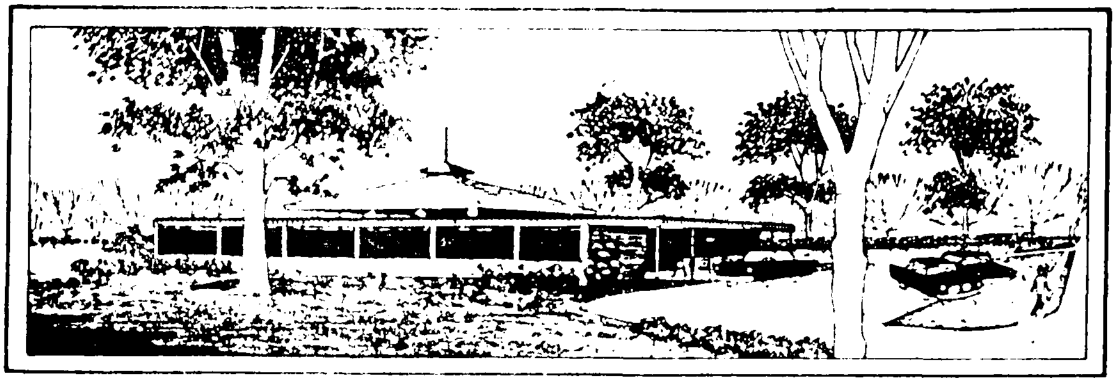
3. No response required.

COUNCILMEN
WARD ONE
JAMES H. WILHELM
8930 Shannonaire
WALTER C. WILHELM
2427 Akins Drive

WARD TWO
MELVIN C. FOEHSE
9412 Bluegrass
LEONARD J. SOBERALSKI
8823 May Avenue

WARD THREE
WALTER KRUZICH
7331 Harney Avenue
JOSEPH H. PROMAROLI
5608 Sapphire

WARD FOUR
EDWARD TYBURA
5635 Janet Ave.
W. F. BULLERDIECK
5255 Helen



City of Jennings — William D. Tharp, Mayor
CITY HALL ● 2120 HORD AVE. ● JENNINGS, MO. 63136 ● PHONE 388-1164

RESOLUTION

WHEREAS, the Department of the Army is engaged in a study of the Maline Creek watershed flooding and related land resource problems; and

WHEREAS, the Maline Creek abutts Koenemann Park on the north;

NOW, THEREFORE, BE IT RESOLVED BY THE CITY COUNCIL OF THE CITY OF JENNINGS, MISSOURI, as follows:

That the Mayor of the City of Jennings does not concur with the recommendations made in the report. The Maline Creek within the City of Jennings has extensive erosion and flooding problems, and be it further resolved that the problem within the City of Jennings can be corrected by installation of rip rap or any other erosion control.

Passed and approved by the City Council of the City of Jennings, Missouri on July 14th, 1980.

W D Tharp
WILLIAM D. THARP, Mayor

ATTEST:

City Clerk

Our Goal Is Continued Progress

COMMENT RESPONSE SHEET

City of Jennings resolution dated 14 July 1980.

Reference paragraph number:

1. No response required.

2. No response required.

3. The 14 July 1980 resolution was read by Mayor Tharp at the 15 July 1980 Maline Creek public meeting. The Corps of Engineers assured Mayor Tharp that streambank protection along the north edge of Koenemann Park would be included in the selected plan based on the city's request and erosion experience. Mayor Tharp then said that the city of Jennings supports the selected plan.

4. No response required.

Missouri Chapter
of the
American Fisheries Society

CHARTERED MARCH 10, 1964

3526 S. Rock Beacon Road
Jefferson City, Missouri 65101
August 1, 1980

Mr. Jack R. Niemi, Chief
Engineering Division
St. Louis District
Corps of Engineers
210 N. Tucker Boulevard
St. Louis, Missouri 63101

Dear Mr. Niemi:

Thank you for the opportunity to review and comment on the Maline Creek Draft Survey Report. Overall, we find the document very well written, and feel that the project will accomplish flood control objectives while minimizing aquatic habitat degradation.

Maline Creek is an urban stream that suffers mainly from poor water quality. With the resolution of these pollution problems through existing programs, the potential for fish population reestablishment increases. We believe that the channel enlargement and straightening proposed in the draft report will impair the reinvasion of fish populations, although the severity of this impact is ameliorated by the 18 aquatic habitat structures. We feel that it would be more ecologically sensitive to confine your activities only to channel enlargement and to cancel those aspects of the plan that call for the construction of new channels and the abandonment of old channels.

The channel enlargement aspects, with the aquatic habitat structures in place, will provide some fish habitat, but we feel that some instream cover would complement the structures nicely. We believe, however, that the best means of maintaining instream cover is a well managed floodplain, and hence we applaud the efforts to establish a stream corridor. Riparian vegetation not only contributes to instream cover, but it also protects the stream against overheating during the warm summer months.

We look favorably on the planned construction of several detention basins, and hope that they will be placed in public ownership and managed as an urban fishery. The Missouri Department of Conservation, in its Urban Fishing Program, currently manages 9 park lakes in St. Louis and vicinity, and we feel the detention basins may have the potential of being managed as urban fishing lakes. As the project nears completion and the details of these basins become known, we feel that the Corps should request the Missouri Department of Conservation to assess their potential for public fishing.

The Missouri Chapter of the American Fisheries Society thanks the St. Louis District Corps of Engineers for the opportunity to comment on the Maline Creek Draft Survey Report.

Sincerely,

Richard E. Wehnes

Richard E. Wehnes, Chairman
EIS Review Committee
Missouri Chapter, AFS

REW:ljm

COMMENT RESPONSE SHEET

American Fisheries Society letter dated 1 August 1980.

Reference paragraph number:

1. Comment noted.

2. The Corps of Engineers has examined many alternatives during the Maline Creek study and we feel that the features recommended are all essential to accomplishing the flood control purpose, while minimizing fish and wildlife habitat degradation. We will be studying the potential for preserving channel cutoffs as aquatic habitat during post-authorization studies, and would welcome your input into that effort.

3. Concur.

4. The Corps of Engineers will coordinate with the Missouri Department of Conservation during the final planning phases to determine possible Department of Conservation participation in public fishing and other aspects of the project.

5. No response needed.

REITZ & JENS, INC.
CONSULTING ENGINEERS
111 SOUTH MERAMEC AVENUE
ST. LOUIS, MISSOURI 63105
(314) 727-0403

NEW ADDR...
1040 N. LINDBER...
ST. LOUIS, MO. 63132

HENRY M. REITZ, PRESIDENT
STIFEL W. JENS, SENIOR VICE PRESIDENT
... J. BAILEY, JR., VICE PRES., CHIEF ENG.
... E. MURRAY, VICE PRESIDENT
DONALD S. ESKRIDGE, SECRETARY

SOIL MECHANICS-FOUNDATIONS
HYDROLOGY-HYDRAULICS
RESOURCE RECLAMATION
DRAINAGE-PAVEMENTS
LAND DEVELOPMENT
WATER RESOURCES
SOLID WASTE

July 16, 1980

Colonel Robert Dacey, District Engineer
St. Louis District, Corps of Engineers
210 N. Tucker Blvd.
St. Louis, MO 63101

Re: Maline Creek Survey Report

Dear Colonel Dacey:

We appreciate the cooperative communication we have had with the Corps in your study and development of possible alternatives as you approached the Environmental Quality Plan for Maline Creek Watershed.

From prior discussions, we anticipated but did not see a long paragraph or more discussing the storm of April 11, 1979. We're aware of the detailed treatment of this actual storm event with comparative evaluation of the recommended plan against actual observations for Maline Creek. This treatment within itself suggests the uniqueness and importance of this storm in the public's awareness of flooding in the St. Louis area. We know the District has spent considerable effort beyond Maline Creek report studying the April 11 1979 storm.

A comparison of the precipitation masses for their duration with observed flood elevations in various parts of the metropolitan area, suggests a significant anomaly. The very brief summarization that from the numerous locations at which rainfall records were gathered, the lowest annual probability was about P=0.20 while from the flooding at major intersections or transportation crossings of streams, there were several flood stages with an annual probability of about 0.01 from FIA studies. Our understanding, early this year, was that Maline Creek report would be the one place in which this hydrologic anomaly would become a part of a reasonably easily accessible public record. In looking at the report and appendices, I don't feel this has been done. It think it is extremely important need for the metropolitan St. Louis record and I urge that something of this nature be added.

If there are any questions about my hopes for some definitive statement, kindly let me know.

Very truly yours,

HENRY M. REITZ

HMR/rs
cc: D. Rahubka

COMMENT RESPONSE SHEET

Reitz and Jens, Inc. letter dated 16 July 1980.

The Corps of Engineers responded to the letter from Mr. Reitz with a letter dated 8 August 1980. This letter and Mr. Reitz's hand written comments on page D-52 of APPENDIX D are attached.

DEPARTMENT OF THE ARMY
ST. LOUIS DISTRICT. CORPS OF ENGINEERS
210 TUCKER BOULEVARD. NORTH
ST. LOUIS. MISSOURI 63101

REPLY TO
ATTENTION OF

LMSED-H 8 August 1980

SUBJECT: Draft Maline Creek Survey Report of June 1980

Mr. Henry M. Reitz, President
Reitz & Jens, Inc.
Consulting Engineers
1040 N. Lindburgh
St. Louis, MO 63132

Dear Mr. Reitz:

I wish to express again my appreciation for the effort and interest that you have shown in storm water developments in the greater St. Louis Metropolitan Area.

In response to your letter of 16 July 1980, I suggest your attention to paragraph 36, of Appendix D, on page D-52 of the referenced report. This paragraph summarizes the data and analysis, with references, that are available for the storm of 11 April 1979. The volume of this report may have made it quite difficult to locate this paragraph.

A great deal of additional information was collected for this storm in other watersheds. This information will be presented in future reports related to those watersheds.

I trust the above reference will satisfy your interest. Should you desire detailed information on this subject, please contact Mr. J. T. Lovelace, the chief of our Hydrologic and Hydraulics Branch (263-5849).

Sincerely,

Arthur L. Johnson

ARTHUR L. JOHNSON
Acting Chief, Engineering Division

reviewed and field checked. Only the bridges at Dunn Road/I-270 (MD mile 2.8) and Berwyn Drive (MC mile 0.5) were found to be significantly in error or not representative of present (1980) conditions. All profiles for the standard project flood at the Dunn Road bridge were recomputed and adjusted reflected on PLATES D-46, D-96, D-220, D-333. The Berwyn Drive bridge has been supplemented downstream by a culvert. No adjustments were considered justifiable at Berwyn Drive.

Verification

36. On April 11, 1979 a storm of considerable similarity to the design storm occurred in the St. Louis metropolitan area. Extensive rainfall and highwater data were collected. An isohyetal map is presented in PLATE D-8. Appropriate rainfall hyetographs are shown in PLATES D-189 through D-193. Highwater marks are illustrated on the water surface profiles (PLATES D-5 through D-16). Utilizing the hydrologic model (HEC-1, JOPER = 3) discharge hydrographs (PLATES D-194 through D-202) were computed for future conditions with and without the selected plan. Only the third burst of rainfall was simulated, with base flow and the loss rate parameters, STRKR and DLTKR, adjusted to a level appropriate to a 10 percent probability flood. Utilizing HEC-2 rating curves, the recorded peak discharges were reproduced within ± 10 percent throughout the basin. Stage hydrographs for the simulated flood are attached as PLATES 203 through 213. These computations served to verify the hydraulic performance of the selected plan including design refinements. Brief calculation of economic damages, based upon the final profile set, verified the flood damage performance of the selected plan.

8/13 Talked with Art Johns

8/14 Talked with Fred Bode

8/14 This does not adequately discuss 4/11/79 for apparent contradictions. Tacit agreement is to discuss this storm specifically as per 7-16-80 letter in other watershed reports, especially River Des Peres

MALINE CREEK, MISSOURI

SURVEY REPORT FOR FLOOD CONTROL
AND ALLIED PURPOSES

APPENDIX D

HYDRAULICS AND HYDROLOGY

APPENDIX D

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HYDRAULIC-HYDROLOGIC CHARACTERISTICS OF THE WATERSHED

Storm Characteristics

1. The Maline Creek flood plain area is subject to flooding of relatively short duration and highly variable severity as a result of high intensity rainfall from thunderstorm cells produced by atmospheric instability. Storms which produce high intensity rainfall can occur at any time of year in the St. Louis area. Severe storms are most likely to occur during a 4-month period from May through August, with slightly higher probability in late spring or late summer. High intensity storms during the winter months are rarely recorded. The seasonal probability of intense 1-hour, 6-hour, and 24-hour rainfalls within the Missouri-Kansas region from storms of various return intervals is shown in PLATE D-2. Rare combinations of meteorological events, such as the world record rainfall of 12 inches in 42 minutes at Holt, Missouri, on 22 June 1947, or the 16.5 inches of rainfall in 9-1/2 hours recorded in East St. Louis, Illinois, on 14-15 June 1957 (PLATE D-1), are not precluded from occurring over the Maline Creek watershed by any known meteorological or topographical factors.

2. As a result of the topographic features and extensive drainage system in Maline Creek, storms of low intensity and long duration generally will not cause extensive flooding of the flood plain area of Maline Creek. Major climatic events of a regional nature, such as the rainfall and floods of April, May, and June 1957 (discussed in the U. S. Weather Bureau Technical Paper No. 33), may well increase the probability of an intense storm over a smaller area such as the 14-15 June 1957 event. An extensive study into the effects of urban-induced rainfall, "Summary Report of Metromex Studies, 1971-72," by the Illinois State Water Survey, et al., offers some insight into summer thunderstorm characteristics in the

Maline Creek watershed. The study concludes that the 1971-72 storm rainfall period in the St. Louis metropolitan area exhibits less than normal precipation but with increased frequency and severity in areas downwind of industrial centers. Based upon examination of the Metromex study, it was concluded that the rainfall depth-frequency relation for the Lambert-St. Louis International Airport weather station, located about 6 miles west of the Maline Creek watershed's geographic center, will be typical of that experienced within the watershed and that the effects of orographic and urban rainfall enhancement will be negligible.

Historical Storms and Floods

3. The streamflow data available for simulation of hydrologic events on Maline Creek is limited to unpublished data from the U. S. Geological Survey since 1968 at the stream gage stations shown in PLATE D-3. This short length of record precludes meaningful statistical flow-frequency analysis of the available discharge data. There are no published data from long-term streamflow gages for the Maline Creek watershed or on other similar streams in the region suitable for hydrologic computations. Recorded streamflow data for some recent storm events, summarized in TABLE D-1, were furnished by the U.S.G.S., together with associated rainfall (TABLE D-2). Both TABLE D-1 and D-2 present excerpts from data tabulated at 5-minute intervals. High water mark information for these events is provided in TABLE D-3. Additional high water mark profiles for the storm of 14-15 June 1957 on the main channel, Dellwood Creek (Tributary MD-1), and Blackjack Creek (Tributary MD), as published by the U.S.G.S., in 1968 in an open file report entitled, "Floods in Maline Creek Basin, St. Louis County, Missouri" are shown in PLATES D-41 through D-52 (see PLATE A-4 for location of designated tributaries). Historical storm isohyetal data are shown in PLATES D-4 through D-8.

TABLE D-1
MALINE CREEK
RECORDING STREAMFLOW DATA

Location	Drainage Area (Sq. Miles)	Avail. Storm Events	Peak Discharge (cfs)
Main channel at Glen Owen Drive	12.36	28-29 Jun 1969	5228.
		9-10 Jul 1969	3730.
		23-24 Apr 1969	6170.
Blackjack Creek at Chambers Road	6.64	9-10 Jul 1969	4410.
		18-19 Apr 1969	2234.
		23-24 Apr 1970	2584.
Main channel at Bellefontaine Rd.	24.62	18-19 Apr 1970	4776.
		23-24 Apr 1970	5175.

TABLE D-2
MALINE CREEK
TOTAL RAINFALL IN INCHES FOR EACH EVENT

Gage	Event 28-29 June 1969	9-10 July 1964	18-19 April 1970	23-24 April 1970
06-9361.35	.92	.97	2.23	2.40
06-9363.80	*	*	1.76	1.86
06-9365.00	*	.74	2.11	1.66
07-0019.50	.98	1.30	*	*
07-0020.00	*	*	2.40	2.29
07-0100.16	.95	.84	*	2.33
Glen Owen Dr.	1.78	1.09	2.39	2.42
Lambert Field (Airport)	2.10	*	*	2.37

* No Data

TABLE D-3
MALINE CREEK
HIGH WATER MARKS (MSL)

Location	Storm Event 14-15 June 1957	28-29 June 1969	9-10 July 1969	18-19 April 1970	23-24 April 1970	11 April 1979
Main Channel at:						
U.S. Highway 367	444.0	435.7	435.8	435.0	436.8	442.2
Glen Owen Drive	460.5	453.1	451.7	451.9	454.3	456.9
W. Florissant Rd.	467.0	458.5	456.9	457.2	459.6	462.1
Bermuda Avenue	481.0	475.1	473.4	473.6	475.5	480.7
Florissant Road	486.0	479.1	477.0	477.2	480.3	485.5
Blackjack Creek (MD) at:						
Chambers Road	455.0	450.0	451.4	447.9	448.7	451.1
Hudson Drive	466.5	460.7	462.0	459.7	459.6	462.1
I-270	*	*	473.2	471.9	472.0	*
Dellwood Creek (MD-1) at:						
Green Valley Dr.	467.0	463.7	463.1	460.5	461.0	*
Imperial Drive	473.5	471.1	*	469.1	469.6	*
Clairmont Drive	475.5	473.4	473.1	470.8	471.4	*

* Not Available

Streamflow Modeling

4. The shortage of recorded historical flood information for this study required that the magnitude of the flood problems be assessed by simulating the watershed's hydrologic and hydraulic response to a series of hypothetical storms and floods. The hydrologic and hydraulic simulation was accomplished using two basic tools:

a. For the hydrologic modeling of hypothetical storm events, the "HEC-1 Flood Hydrograph Package" computer program, developed by the Hydrologic Engineering Center, U.S. Army Corps of Engineers, Davis, California, was used. The hydrologic model was calibrated and verified by reconstituting the available recorded historic events (See PLATES D-12 and D-13).

b. For the hydraulic modeling of the Maline Creek stream system, the "HEC-2 Water Surface Profiles" computer program, also developed by Hydrologic Engineering Center, was used. Calibration and verification of the hydraulic model was accomplished by comparing computed highwater marks to the available historical highwater marks (See PLATE D-9 through D-11).

5. In order to successfully simulate the combined hydrologic/hydraulic effects within the watershed, the independently derived models were then linked together by using hydrologic peak discharges produced by HEC-1 as input to HEC-2, and by using storage-discharge relationships produced by HEC-2 as input to HEC-1's hydrograph routing routine. The following paragraphs expand on the specific procedures used to simulate the watershed's hydrologic and hydraulic responses and the specific results obtained using these two models.

Hydrologic Modeling

6. Unit hydrographs and flood routing provided the basis for the hydrologic simulation of the rainfall-runoff response of the Maline Creek watershed. Rainfall depths for 5-minute intervals from historical storms and hypothetical storms were applied to individual unit hydrographs for each of the 46 subareas developed for this study, yielding flood hydrographs for each of the subareas. See PLATE D-14 and TABLE D-4 for a description of the subareas. These flood hydrographs were then routed and combined starting from the headwaters working towards the mouth of the main channel. Flood hydrographs for a typical subarea and the combined and routed hydrographs with associated hypothetical rainfall distributions for selected index stations along the main channel are illustrated in PLATES D-15 through D-19 for a range of hypothetical floods. Hypothetical storms of a given frequency, or return interval, were derived from the depth-intensity duration relationships contained in the U. S. Weather Bureau Technical Paper No. 40. The cumulative distribution of the frequency storm used for this study is shown in PLATE D-20. Rainfall depths for a given frequency, at 5-minute intervals, were arranged in a sequence considered to be critical for runoff as constrained by the depth-duration relationship of Technical Paper No. 40. Frequency rainfall arrays for a point station were plotted together with the resulting runoff hydrographs as previously shown in PLATES D-15 through D-18. The Standard Project Storm rainfall mass curve, shown in PLATE D-21, along with the resultant hydrographs (PLATE D-19) were computed to present the most severe flood-producing rainfall depth-area-duration relationship and isohyetal pattern of any storm that is reasonbly characteristic of the region. Rainfall increments associated with this rare event were computed using the method provided in the Corps of Engineers' Engineering Manual (EM) 1110-2-1411, entitled, "Standard Project Flood Determinations."

TABLE D-4
MALINE CREEK
SUBAREA CHARACTERISTICS

Subarea No.	Drainage Area (sq mi)	Elevations (msl) Lowest	10% of Length	85% of Length	Highest	Flowage Length (mi)	Average[1] Slope (ft/mi)
101	.40	402.4	430	480	513	.75	89
102	.37	414	434	500	513	.67	132
1021	.54	441.5	457	525	559	.90	100
1022	.56	446	453	515	592	1.41	58
103	.48	415.3	432	490	518	.65	118
1031	.78	439.2	450	545	574	.80	158
1032	.38	519	521	525	550	1.04	5
1041	.50	446	467	500	550	1.07	41
1042	.35	480	490	537	584	.66	94
105	.32	430	447	503	535	.96	77
1051	.34	425	432	500	575	.78	115
1052	.51	436.5	457	498	515	.64	85
106	.48	432	450	525	575	.72	134
107	.62	441.1	459	525	560	.56	157
1071	.36	435.1	458	530	600	.96	100
108	.44	442	463	533	600	1.54	65
1081	.39	443	470	536	590	1.12	79
109	.22	449.5	471	503	539	.64	67
1091	.38	494.5	510	565	605	.40	183
1092	.30	513.5	534	595	637	.73	111
110	.62	459	480	575	623	1.68	75
1101	.56	450	473	532	620	1.38	57
111	.31	470.4	486	575	599	.80	48
1111	.95	485.5	505	565	644	1.02	78

TABLE D-4 (Continued)
MALINE CREEK
SUBAREA CHARACTERISTICS

Subarea No.	Drainage Area (sq mi)	Elevations (msl) Lowest	10% of Length	85% of Length	Highest	Flowage Length (mi)	Average[1] Slope (ft/mi)
1112	1.05	512	515	625	670	1.28	115
1113	1.02	540	555	595	633	.43	125
1114	.32	545	550	620	666	.83	113
112	.72	484	505	555	635	1.14	58
1121	.26	476.5	493	560	624	1.12	80
113	.26	497.1	505	560	603	.35	212
1131	.33	501.5	515	600	637	.93	121
1132	.53	523	527	590	630	.66	125
114	.88	506	525	646	656	1.14	141
1141	.21	503	510	572	603	.26	310
115	.71	531	555	620	632	.43	203
116	1.18	498	554	640	665	.94	121
118	.39	464.2	483	525	555	.43	131
1181	.36	460	470	545	598	1.12	89
119	.55	477.5	497	565	605	.88	103
120	.99	493.8	505	583	666	1.44	72
121	1.18	451.5	467	540	612	1.44	68
122	.56	472.5	500	580	620	.83	129
123	.85	485	505	585	638	1.04	102
124	.29	475	500	540	610	.53	100
125	.99	485	490	570	630	1.36	78
126	.48	522	525	585	655	.67	120
Total	25.27	N/A	N/A	N/A	N/A	41.13	N/A

[1] Represents slope between points at 10% and 85% of length.

The depth-area reduction implied by both Technical Paper No. 40 and EM 1110-2-1411 was accomplished using the "consistent hydrograph" method incorporated into HEC-1, operated in the "stream system" mode (JOPER = 4). This depth-area relation is shown in PLATE D-22.

7. The parameters required for computing unit hydrographs were based upon several methods and procedures. The "Clark" method unit hydrographs used in the HEC-1 computer program required the specification of the following unit graph parameters:

TC	Time of Concentration
R	Recession Coefficient
RTIMP	Percent of Subarea Impervious

For this study, the most sensitive parameter, "TC" was calculated using the methods of Soil Conservation Service Technical Release No. 55 entitled, "Urban Hydrology for Small Watersheds", published in January, 1975. The impervious percentage used was based upon the land use and population density data for existing conditions (TABLE D-5), and for projected future without project conditions (TABLE D-6). Clark's recession coefficient, "R", was estimated conservatively as one-half of the "TC". The time-area curve, a normally insensititive parameter, was generalized by the HEC-1 program. Minor adjustments to the time of concentration to account for present and future construction of improved channels within the subasin watersheds was accomplished using procedures similar to the "Percent of Hydraulic Length Modified" method described by TR 55. A program of such improvements was initiated by the MSD during the study and was assumed to be essentially completed by the year 2020. This hydraulic adjustment was achieved by the following steps:

a. Determination of basic SCS curve numbers from available SCS soils mapping for present conditions.

b. Adjustment of present and future condition SCS curve numbers for urbanization considering impervious percentage and population density (TABLE D-5).

c. Determination of the effect of existing and future channel improvements upon watershed lag by use of FIGURE 3-4, page 3-8, SCS TR55.

d. Conversion of SCS lag to time of concentration using:

$$LAG = .6T_c$$

Details of the above steps are not further documented herein since the net effect of the urbanization adjustments were reasonable, consistent and not highly significant in the Maline Creek situation.

8. It is recognized that for storms of rare probability, a portion of the subarea runoff would arrive at the point of concentration by means other than the normal path through the storm sewer system (i.e., streets and overland). This distinction was deemed insignificant with considerations of the topography of the Maline Creek watershed. The overall criteria used to develop the subarea unit hydrographs were conservative. Peak flows could occur earlier and higher in the model than what could reasonably occur in thenatural stream . However, this condition is dampened out and essentially compensated for in the channel routing process. Unit hydrograph parameters used are listed in TABLE D-7.

9. The second step for computing subarea flood hydrographs involved the estimation of rainfall loss rates, antecedent conditions, and base flow recession functions. Two loss rate parameters, STRKR (the basic loss index) and DLTKR (the incremental loss index) were used for this study. TABLE D-8 lists the values of

TABLE D-5
MALINE CREEK
EXISTING LAND USE- POPULATION DENSITY
AND PERCENT IMPERVIOUS BY SUBAREA (1975)

Subarea Number	Total Acres	Density (Pop./Ac.)	Res. (%)	Comm.-Ind. (%)	Inst.-Rec. (%)	Ag.Vac. (%)	Percent Impervious
101	256	3.9	30.1	60.2	0	[illegible].7	19
102	237	2.9	21.9	0	33.8	44.3	18
1021	346	8.7	67.2	4.3	7.4	21.1	28
1022	358	8.2	63.2	.6	19.9	16.3	28
[illegible]3	179	8.4	64.2	0	16.2	19.6	28
1031	499	10.5	81.0	1.0	8.0	10.0	33
1032	243	2.7	20.6	0	79.4	0	18
1041	448	7.3	56.4	16.3	22.8	4.5	26
1042	224	0.2	1.7	0	98.3	0	12
105	211	11.2	85.8	10.8	1.0	2.4	35
1051	211	4.3	33.3	19.0	0	47.8	21
1052	326	10.4	80.1	9.2	1.5	9.2	33
106	262	9.7	74.9	0	18.1	7.0	32
107	442	11.0	84.5	1.4	0	14.1	35
1071	230	10.8	82.9	0	0	17.1	33
108	365	9.5	73.4	17.4	4.2	5.0	32
1081	250	3.8	29.4	58.0	12.6	0	19
109	58	4.5	35.3	0	43.1	21.6	21
1091	243	12.8	98.8	0	0	1.2	37
1092	192	12.3	94.2	0	0	5.8	37
110	397	10.0	77.2	9.5	4.0	9.3	32
1101	358	2.7	20.6	11.2	38.7	29.5	18
111	198	11.2	86.5	6.2	4.7	2.6	35
1111	608	8.2	63.2	9.6	12.4	14.8	28

TABLE D-5 (Continued)
MALINE CREEK
EXISTING LAND USE- POPULATION DENSITY
AND PERCENT IMPERVIOUS BY SUBAREA (1975)

Subarea Number	Total Acres	Density (Pop./Ac.)	Res. (%)	Comm.-Ind. (%)	Inst.-Rec. (%)	Ag.Vac. (%)	Percent Impervious
1112	672	7.2	55.7	0	29.8	14.5	26
1113	653	9.9	76.5	12.5	7.9	3.1	32
1114	205	12.2	94.2	4.4	0	1.4	37
112	461	12.4	95.0	0	2.2	2.8	37
1121	166	11.7	89.8	0	0	10.2	35
113	166	6.3	48.7	6.0	0	45.3	25
1131	211	12.5	96.2	1.9	1.9	0	37
1132	339	4.0	30.6	4.5	8.6	56.3	19
114	563	9.2	71.1	7.1	0	21.8	30
1141	134	0.7	5.0	7.0	5.8	82.2	12
115	454	10.9	83.7	1.5	3.1	11.7	33
116	787	8.5	65.5	5.6	9.0	19.9	28
118	237	11.3	87.0	0	6.3	6.7	35
1181	211	12.3	94.8	0	0	5.2	37
119	352	10.2	78.0	7.5	3.1	11.4	32
120	634	5.1	39.3	0	22.4	38.3	22
121	755	8.8	67.4	2.6	13.9	16.1	28
122	358	9.3	71.6	.9	19.1	8.4	30
123	544	7.9	60.5	.7	15.8	23.0	29
124	186	4.5	34.9	60.2	2.2	2.7	21
125	634	5.9	45.4	7.9	0	46.7	25
126	307	0.8	5.9	1.5	37.5	55.1	13

TABLE D-6
MALINE CREEK
FUTURE LAND USE - POPULATION DENSITY
AND PERCENT IMPERVIOUS BY SUBAREA (2020)

Subarea Number	Total Acres	Density (Pop./Ac.)	Res. (%)	Comm.-Ind. (%)	Inst.-Rec. (%)	Ag.Vac. (%)	Percent Impervious
101	256	4.7	31.2	60.2	0	8.6	21
102	237	6.2	40.9	0	42.2	16.9	25
1021	346	12.5	82.7	4.3	13.0	0	37
[illegible]	358	10.9	71.5	8.9	19.6	0	33
103	179	12.7	83.8	0	16.2	0	35
1031	499	13.7	90.2	1.0	8.8	0	40
1032	243	3.1	20.6	0	79.4	0	18
1041	448	8.5	56.4	16.3	25.7	1.6	28
1042	224	0.3	1.7	0	98.3	0	12
105	211	13.0	85.8	10.8	1.0	2.4	38
1051	211	11.6	76.3	18.9	0	4.8	35
1052	326	12.2	80.1	9.2	1.5	9.2	37
106	262	11.4	74.9	0	18.1	7.0	35
107	442	12.9	85.0	4.8	0	10.2	37
1071	230	12.9	85.0	10.7	0	4.3	37
108	365	11.1	73.4	20.0	4.2	2.4	35
1081	250	4.4	29.4	58.0	12.6	0	21
109	58	6.0	40.0	5.0	50.0	5.0	25
1091	243	15.0	98.8	0	0	1.2	42
1092	192	14.8	97.4	0	2.6	0	42
110	397	11.7	77.2	15.0	7.8	0	35
1101	358	4.7	31.3	30.0	38.7	0	21
111	198	13.1	86.5	6.2	4.7	2.6	38
1111	608	10.6	70.0	10.0	15.0	5.0	33

TABLE D-6 (Continued)
MALINE CREEK
FUTURE LAND USE - POPULATION DENSITY
AND PERCENT IMPERVIOUS BY SUBAREA (2020)

Subarea Number	Total Acres	Density (Pop./Ac.)	Res. (%)	Comm.-Ind. (%)	Inst.-Rec. (%)	Ag.Vac. (%)	Percent Impervious
1112	672	8.6	57.0	32.4	0	10.6	28
1113	653	11.6	76.5	12.5	11.0	0	35
1114	205	14.3	94.2	4.4	0	1.4	40
112	461	14.4	95.0	2.2	0	2.8	40
1121	166	13.6	89.8	0	0	10.2	40
113	166	12.2	80.1	12.1	0	7.8	37
1131	211	14.6	96.2	1.9	1.9	0	41
1132	339	4.7	30.6	4.5	64.9	0	21
114	563	12.1	79.9	16.0	0	4.1	37
1141	134	0.8	5.0	51.5	5.8	47.7	13
115	454	12.7	83.7	10.0	3.1	3.2	37
116	787	10.1	66.5	14.4	10.6	8.5	32
118	237	13.2	87.0	0	7.0	6.0	38
1181	211	14.4	94.8	0	0	5.2	41
119	352	12.2	80.0	10.0	7.1	2.9	37
120	634	7.0	46.2	0	53.8	0	26
121	755	12.1	79.9	5.6	13.9	.6	37
122	358	11.4	75.0	1.0	20.0	4.0	35
123	544	9.9	65.0	3.0	28.0	4.0	32
124	186	5.3	34.9	62.9	2.2	0	22
125	634	9.9	65.0	15.0	0	20.0	32
126	307	6.1	40.0	12.5	37.5	10.0	25

these parameters associated with selected hypotehtical storms. The rainfall loss exponent, ERAIN, was standardized at 0.[illegible] by St. Louis District Regional criteria. The base flow recession, RTIOR, was computed as 1.5 from observed hydrographs. The overall criteria used to select the loss condition parameters are considered to be a realistic duplication of the volume of runoff from storms of varying magnitude.

10. The channel routing and combining of flood hydrographs in the HEC-1 hydrologic model used the "Stream System" computation routing of the HEC-1 computer program. Flood hydrographs and their combinations were routed through 69 hydrologic channel reaches. The basic criterion for selecting these reaches was that the travel time of flow in a reach must not be less than the hydrograph routing interval nor more than three times that interval. Reach selection was constrained as well by other factors such as topography, economics, and the basic assumptions implicit in the adopted "Modified Puls" type of routing. All routing reaches are characterized by a distinct relationship of storage to outflow discharge. These storage-outflow (discharge) relationships were developed by the HEC-2 hydraulic model discussed in the next paragraph. Index stations are shown in PLATE D-23. The hydrologic model, as a whole, was verified by reconstituting the historical events (PLATES D-12 and D-13) observed in the watershed. The computed discharge-frequency curves for selected stations, as developed by the HEC-1 hydrologic model, are included as PLATES D-53 through D-56.

TABLE D-7
MALINE CREEK
UNIT HYDROGRAPH PARAMETERS

	Existing Conditions			Future Conditions		
Subarea	TC	R	RTIMP	TC	R	RTIMP
101	.28	.14	.19	.24	.12	.21
102	.32	.16	.18	.24	.12	.25
1021	.26	.13	.28	.20	.10	.37
1022	.25	.13	.28	.18	.09	.33
103	.29	.15	.28	.22	.11	.35
1031	.29	.15	.33	.22	.11	.40
1032	.70	.35	.18	.64	.32	.18
1041	.15	.07	.26	.09	.05	.28
1042	.51	.26	.12	.48	.24	.12
105	.30	.15	.35	.23	.12	.38
1051	.26	.13	.21	.19	.10	.35
1052	.16	.08	.33	.13	.06	.37
106	.26	.13	.32	.21	.11	.35
107	.22	.11	.35	.16	.08	.37
1071	.18	.09	.33	.14	.07	.37
108	.35	.17	.32	.28	.14	.35
1081	.38	.19	.19	.35	.18	.21
109	.16	.08	.21	.11	.06	.25
1091	.11	.05	.37	.08	.04	.42
1092	.16	.16	.37	.13	.07	.42
110	.32	.16	.32	.20	.10	.35
1101	.46	.23	.18	.34	.17	.21
111	.22	.11	.35	.16	.08	.38
1111	.24	.12	.28	.20	.10	.33
1112	.30	.15	.26	.24	.12	.28
1113	.43	.22	.32	.33	.17	.35
1114	.19	.10	.37	.15	.08	.40
112	.28	.14	.37	.21	.11	.40
1121	.21	.11	.35	.17	.09	.40
113	.15	.08	.25	.12	.06	.37
1131	.26	.13	.37	.20	.10	.41
1132	.26	.13	.19	.24	.12	.21
114	.26	.13	.30	.20	.10	.37

TABLE D-7 (Continued)
MALINE CREEK
UNIT HYDROGRAPH PARAMETERS

	Existing Conditions			Future Conditions		
Subarea	TC	R	RTIMP	TC	R	RTIMP
1141	.57	.28	.12	.44	.22	.13
115	.28	.14	.33	.21	.11	.37
116	.37	.19	.28	.30	.15	.32
118	.24	.12	.35	.19	.10	.38
1181	.35	.18	.37	.29	.15	.41
119	.21	.11	.32	.18	.09	.37
120	.48	.24	.22	.35	.18	.26
121	.50	.25	.28	.35	.18	.37
122	.30	.15	.30	.25	.13	.35
123	.38	.19	.29	.34	.17	.32
124	.20	.10	.21	.17	.09	.22
125	.52	.26	.25	.39	.20	.32
126	.33	.17	.13	.21	.11	.25

TABLE D-8
MALINE CREEK
LOSS RATE PARAMETERS

Return Period Years	STRKR	DLTKR
1, 2, 5	0.2	3.0
10	0.2	2.8
25	0.2	2.5
50	0.1	2.0
100	0.1	1.0
500	.08	.8
Standard Project	.06	.8

Hydraulic Modeling

11. The second basic tool used to simulate the Maline Creek watershed's response to flood-producing storms was the HEC-2 hydraulic model. This model uses basic topographic data in the form of surveyed channel and valley cross sections, peak flood discharges from the HEC-1 hydrologic model, and engineering estimates of energy loss factors and coefficients to calculate the elevation of the water surface profiles for each of the hypothetical floods. Rating curves, the stage-discharge relationship computed by the HEC-2 hydraulic model, are shown for selected stations in PLATES D-57 through D-59. The topographic basis for hydraulic modeling is derived from surveyed cross sections at 82 locations in the watershed (PLATE D-24) supplemented by bridge cross sections obtained from state and county highway departments. Additional cross section information was obtained from the Metropolitan St. Louis Sewer District in the form of topographic and sewer mapping. Construction plans for recent channel improvements and modifications were also furnished by the above agencies for incorporation into the cross section description of the stream channels. This additional data was utilized to estimate approximately 600 supplemental cross sections for the hydraulic model. Plotted cross sections for selected stations are shown in PLATES D-25 through D-40.

12. Starting water surface elevations for the main stem of the creek were developed by water surface profile computations beginning downstream of Riverview Boulevard. Starting water surface elevations are heavily influenced by a drop structure at mile .490. This structure has a crest length of 36 feet at elevation 412 msl. Starting elevations for tributaries were taken from the main stem profiles at a point generally upstream of the physical junction where the main stem profile no longer overtops the neck of land separating the tributary from the main stem. In order to allow expeditious processing by the computer, these locations were selected as follows:

Tributary	Tributary To	At Milepost
Riverview Branch (MA)	Main Channel	.999
Bellefontaine Branch (MB)	Main Channel	1.722
Moline Acres Branch (MC)	Main Channel	2.200
Blackjack Creek (MD)	Main Channel	2.526
Dellwood Branch (MD1)	Blackjack Creek (MD)	1.394
Central City Branch (MD2)	Blackjack Creek (MD)	2.210
Ferguson Branch (ME)	Main Channel	5.460
Ball Creek Branch (MF)	Main Channel	6.250
Ferguson Branch (MG)	Main Channel	6.325
Kinloch Branch (MH)	Main Channel	7.800

13. Channel and overbank roughness coefficients (Mannings "n") are sensitive variables in hydraulic modeling and serve as a primary means for model calibration. The method used to select roughness coefficients was to compare published values for similar stream reaches, tempered by engineering judgment and experience in comparable watersheds. Recognizing the sensitivity of roughness values to the density of riverine vegetation, the roughness coefficients were selected for anticipated vegetation growth in the critical May though August period of high storm probability.

14. Energy losses in transitions between cross sections in the hydraulic model are influenced by expansions and contractions in the cross sectional areas of the flow. These losses are computed as coefficients of the absolute difference in flow energy between sections in a transition. For this study, these coefficient were

selected by engineering judgment with reference to standard textbook values in a range of 0.1 to 0.3 for contracting transitions and 0.2 to 0.8 for expanding transitions. Energy losses computed in this manner are generally minimal for this study. No attempt was made to use these values during the calibration of the model due to a lack of detailed discharge and water surface elevation data.

15. A major factor in the computation of water surface profiles for Maline Creek was the computation of energy losses caused by the 62 bridges and culverts spanning the channels. The HEC-2 hydraulic model simulated energy losses for these structures by selecting the appropriate combination of open channel, pressure or weir flow in channel, and overbank flow areas. The energy losses in these structures are reflected in the discontinuities shown in the water surface profiles, PLATES D-41 through D-52. These computations, and hence the profiles, do not account for any obstruction of bridge areas by sediment and/or debris or for the structural failure of bridge embankments resulting from erosion or backwater ponding.

16. The general regime of flood flows in the existing Maline Creek channels is subcritical (relatively tranquil). However, supercritical flow does occur in isolated, special situations such as in paved areas, at bridges, in pipes, culverts, and in areas of very steep slopes. None of these supercritical situations were considered sufficient to warrant detailed, separate supercritical profile computations. The computed flood hydrographs (PLATES D-15 through D-19) reveal a wide variation in durations of flooding ranging upwards to more than six hours for a standard project flood at locations near the mouth of the main stem. The discharge at which flooding commences varies considerably throughout the watershed. At stations located in the reach from Bellefontain Road (mile 1.1) to the junction with Black Jack Creek (mile 2.5) flooding

appears to commence in the range of 6,000 to 9,000 cubic feet per second. An indicator of the flood hazard resulting from flow velocities is plotted in PLATES D-60 through D-73. These velocity profiles are average velocities in the channel portion of the cross-section for an event of .01 probability. Maximum channel velocities will be somewhat higher and overbank velocities somewhat lower than those shown. Velocities for other magnitudes of events are generally proportional, i.e., slightly lower for more common flood magnitudes.

17. Verification of the hydraulic model was accomplished by comparing computed highwater profiles against those for the storm and flood of June 1957, published in the report entitled, "Floods in Maline Creek Basin, St. Louis County, Missouri," by Donald W. Spencer and Leland D. Hauth, U. S. Department of the Interior, Geological Survey. The storm was the largest and best documented storm/flood available. Computed gage rating curves were also compared to those furnished by the U.S.G.S., (PLATES D-9 and D-11).

Mississippi River Influence

18. The extent of flooding problems resulting from the Mississippi River upon the Maline Creek watershed can be considered to be minimal. The flood elevations expected at the confluence of Maline Creek and the Mississippi River (Mile 187.2) are:

20 Percent probability	-	418.0
10 Percent probability	-	422.0
4 Percent probability	-	426.2
2 Percent probability	-	429.8
1 Percent probability	-	433.0
Urban design flood	-	438.0

These elevations are indicative of the flood hazard in the Mississippi River flood plain up to Maline Creek river mile .490; the drop structure on Maline Creek. Problems, needs, and proposed improvements in the Mississippi flood plain are addressed in the St. Louis local protection project documents previously referenced. Non-coincidental backwater flooding by the Mississippi River above the drop structure, mile .490, is expected to cause average annual damages of $15,600. The damages do not commence until the river approaches the 2 percent chance elevation. The record 1973 Mississippi River flood reached a maximum elevation of 428.5 at Maline Creek, requiring some flood fighting efforts by local interests to prevent damages. At the very rare elevations of the urban design flood, some backwater would be standing in the channels, below bankfull, at the U.S. 367 bridge at mile 2.149. The consequences of the coincidental flooding of Maline Creek, due to local rainfall and flooding by the Mississippi River, are essentially the same as flooding by the creek itself. The water surface elevations expected to occur resulting from local storms (PLATE D-41) at mile .490 equal or exceed those listed above for the Mississippi River for the same probability of occurrence. Since the joint probability of occurrence of essentially independent events, such as these, is equivalent to the product of the individual probability, the joint occurrence of major flood events on these two streams is a very rare event. Therefore, the expected annual damages will become essentially those of the creek acting alone.

Hydraulic Sensitivity Tests

19. It is recognized that the estimation of roughness factors and energy loss coefficients is a subjective process dependent upon engineering judgment. In addition, the assumption that bridge openings are not obstructed by debris or sediment was adopted due to lack of any objective basis for evaluation. In order to determine the level of significance of these assumptions, a series of

sensitivity tests were conducted [illegible] the [illegible] model in conjunction with the hydrologic and [illegible] model [illegible] the basin. The criterion selected for determination of sensitivity is the percentage of change in expected average annual damages. This criterion was selected to avoid the difficulties associated with the display of hydraulic parameters and because of the complex and diffuse nature of the watershed. Sensitivity parameters were varied to represent essentially maximum errors in the estimates. The results of these tests (TABLE D-9) incorporate the full dynamics of the hydraulic-hydrologic model. The six tests conducted, and an interpolation of the results are as follows:

a. TEST NL. All roughness coefficients (Mannings "n") were reduced 20 percent throughout the basin. The primary characteristics of this change are an overall decrease of system average annual damages by 16 percent. A few reaches show a slight increase in average annual damages as a result of decreased storage upstream of the reach, causing an increase in discharge.

b. TEST NH. All roughness coefficients were increased 20 percent throughout the basin. The result (an average annual damage increase of 11 percent) is essentially the converse of TEST NL.

c. TEST ML. The coefficients of expansion and contraction, set to various levels in the basic hydrologic model, were uniformally set to 0.1 for contraction and 0.3 for expansion. This represents a general reduction of the coefficients. This test results in a net reduction of average annual damages by 7 percent. The impact of changes in these parameters is primarily at bridges where, in general, damages are reduced upstream of the bridge and tend to increase downstream as a result of an increase in discharge.

d. TEST MH. This test is the converse of TEST ML, showing the impact of a general increase in expansion and contraction

TABLE D-9

MALINE CREEK

PERCENT CHANGE IN AVERAGE ANNUAL DAMAGES

DUE TO HYDRAULIC SENSITIVITY TESTS

	APPROXIMATE LEVEL OF TOTAL DAMAGE (Avg. Annual)	TEST					
		NL	NH	ML	MH	DL	DH
M16	114	-20	7	-9	0	0	67
M15	13	-33	22	-18	27	0	329
MH	26	-3	11	0	-4	0	-1
M14	53	-32	68	8	-2	-16	-60
M13	68	-18	41	7	-7	-8	-47
M12	526	-13	18	0	-2	1	12
MG2	476	0	0	0	1	0	3
MG1	14	-32	56	-11	19	1001	1883
MF2	4	11	12	0	2	0	-2
MF1	1	15	56	-13	54	83	90
M11	281	-21	0	-23	2	-2	108
M10	185	-4	15	9	23	49	681
M9	88	-22	18	-5	-5	119	730
M8	351	-29	7	-11	-6	-9	-67
M7	6	2	40	-22	56	-16	-71
M6	137	-9	19	2	21	-3	-50
MD6	11	-19	31	-35	53	25	57
MD5	31	-1	21	-2	57	1	0
MD4	22	-13	69	3	31	33	62
ND3	46	-13	21	1	0	-1	50
MD1-2	35	-15	28	-0	7	11	28
MD1-1	2	-17	29	-4	-4	-9	79
MD2	110	-25	33	0	0	11	23
MD1	20	-30	37	-11	6	3	-5
M5	477	-25	-9	-28	-1	-1	-51
M4	50	-17	3	0	4	8	-18
MC	104	-18	23	-6	21	1	13
M3	59	-25	21	7	-7	-7	-53
MB	19	-62	55	-37	19	7	30
M2	18	-6	19	0	2	13	-29
MA	52	0	0	0	-1	2	267
M1	31	8	-12	15	-3	-13	-52
Net Change	N/A	-16	11	-6	2	9	65

coefficients to 0.5 and 1.0, respectively. The final total, an increase of 2 percent in average annual damages, indicates that the coefficients used for the basic hydraulic model are, in general, closer to those in TEST MH than those in TEST ML. Some reaches (notably M10, M6, MD5, and M.. are located upstream of high velocity bridges and damages are extremely sensitive to estimates of energy loss coefficients.

e. TEST DL. The objective of TEST DL was to show the potential impact of the reduction of bridge cross sectional area due to the accumulation of debris, trash, and sediment. All bridges, where the possibility for pressure or weir flow exists, were reduced in area by 20 percent. If any piers exist at the bridge, half of the reduction was applied to the pier width. The remainder was assumed to accumulate at the channel bottom. These reductions also apply to low flow conditions at the bridges. The net result, an increase of 9 percent in total average annual damage, is overshadowed in significance by the very large changes at reaches M9, M10, and MG1. These reaches are located above bridges where the increased bridge swellheads cause considerably additional damage. Some beneficial effects are noted in downstream reaches as a result of decreased discharges due to storage increases.

f. TEST DH. This test is the same as TEST DL, but with a reduction factor of 50 percent. The overall increase of 65 percent, in total damages, while very dramatic, is less significant than the tremendous damage increase in the Ferguson area: reaches M9. M10, M11, and MG1. These increases are caused by the bridge at West Florissant Avenue and Norfolk and Western Railroad bridge at mile 5.636. Downstream beneficial effects, by storage, are far more pronounced that TEST DL.

g. Sensitivity Test Conclusions. It is considered that the sensitivity tests provided a reasonable verification of both successful model operation as well as the assumptions made regarding input values. The conclusion is based on the observation that the changes in results (as measured by average annual damages) were of a type and general magnitude as would be anticipated by an experienced hydrologic engineer, familiar with the Maline Creek area. It can also be observed that the six factors tested have in some instances offsetting or converse impacts. As a result, any errors in assumed values may be mitigated by a compensating effect. Also tested was the sensitivity of structure location relative to damage reach midpoint. The conclusion was that the damage estimation system used for this study is very sensitive to structure location. In the last sensitivity case cited, considerable additional study and base data would be necessary. It was concluded that the additional refined studies necessary were not appropriate to preauthorization level analysis and could be pursued later, should this project be authorized.

Hydraulic - Hydrology Summary

20. The primary products resulting from the hydrologic and hydraulic modeling are the water surface profiles shown in PLATES D-41 through D-52. These profiles represent the final output of numerous iterations of the computer programs for calibration, verification, and error correction. In those cases where calibration could not be verified by comparison to historical data (i.e., large energy losses at bridges), the calculations were handled primarily by hand computation. Due to the scope and complexity of this study, the computer derived profiles were used exclusively. These existing conditions profiles are annotated with the point of confluence of the tributary streams. These points are not necessarily the same river mile at which the tributary profile was started due to varying degrees of overtopping of the neck of land between the two streams.

Objectives, Constraints, and Scope

21. The analysis of Maline Creek objectives, constraints and scope was pursued via four cycles of formulation. These cycles of formulation progressed from very gross approximations through rather detailed analysis so as to obtain the recommended plan of improvements. The hydrology used in the first two cycles of formulation were of a gross nature and are available for review if so desired, as contained in the July 1973 and January 1974 Draft Maline Creek Survey Reports. Careful Corps of Engineers review of those reports indicated that the hydrology of the study area warranted the more extensive analysis summarized herein. The overall objective of plan formulation was to determine a set of structural and non-structural improvements throughout the watershed which would alleviate the water and related land resource problems with primary emphasis upon flood control. Many impacts of these sets of improvements ("PLANS") are intangible and subjective. Further, many of the available alternatives are competitive and "trade-offs" had to be evaluated. These circumstances require that a large number of alternative plans be created and tested for their tangible and intangible impacts upon the problems and resources of the watershed. This plan formulation process is guided and constrained by the "Principles and Standards of the Water Resources Council" and procedures of the Corps of Engineers primarily resulted from the Water Resources Planning Act of 1965. The bulk of this guidance and constraints is initially directed toward the economic performance of the alternatives and plans. Since the economic performance of a plan is determined by the hydrologic performance, the principle constraints upon hydrologic plan formulation were considered to be:

a. The plan must be economically justifiable.

b. Each separable element of a plan must be individually justifiable in economic terms.

c. Each plan and element must be physically feasible and implementable without any significant adverse impacts.

Hydrologic Basis

22. The plan formulation hydrology was based upon the hydrologic conditions assumed to prevail in the year 2020. This future condition hydrology was primarily limited to the increase in runoff quantity and the change in time of concentration related to increasing urbanization of the few undeveloped areas in the watershed. The changes in percent impervious area (TABLE D-6) and unit graph coefficients (TABLE D-7) were related essentially to existing and estimated future population density by correlation methods. The adjustments for future conditions were relatively insensitive as a result of the existing highly-urban condition. The potential for hydraulic modification, particularly earth fills in the flood plain, at the future condition was tested and was significant. However, it was assumed to be unlikely, based upon current land use, zoning, and the effects of other governmental programs. The future condition hydraulics of the subbasin watersheds was included in the future condition hydrology as described in paragraph 7. Maximum computed water surface profiles for the future condition without project are included for comparison to the detailed plans. Flooded areas are shown in PLATES D-76 to D-87. These areas represent the maximum elevations which could be reached with 10 percent and 1 percent probabilities and upon the occurrence of a Standard Project Flood. It must be carefully understood that the entire area will not be flooded simultaneously

to these levels. For the future condition computations, a "Milepost" system was developed to designate the location of cross sections in the watershed. This resulted from consideration of the potential effect of channel shortening upon the river mile designations. These general locations are shown in PLATE D-75.

Alternatives

24. The following conceptual alternative measures were considered to provide potential positive contributions to the objectives.

a. Detention reservoirs.
b. Channel Improvements.
c. Bridge Modifications.
d. Property Aquisition
e. Relocation of Building Structures
f. Increased Conveyance Capacity of Flood plains and Channels (Clear and Snag)
g. Low Level Flood Protectors and Sewer Modifications

A detailed description of these alternative measures and rationale for screening is given in APPENDIX B. Preliminary estimates of hydrologic and economic performance and construction costs indicated that no single, simple, measure would provide satisfactory achievement of the multiple objectives. The bulk of the hydrologic plan formulation effort was directed toward the systematic assessment of the tangible performance of combinations of the listed alternative measures in various locations, capacities and types.

Methods

25. In order to systematically screen all reasonable combinations of the alternative measures, a digital computer simulation model of

the hydrology and flood damage economics of the watershed was developed for this study. This "model" consisted of an extension of the hydrologic and hydraulic computer programs and data utilized in the problem identification stage of the study supplemented by economic damage data and programs. Since many of the individual alternatives under consideration have very subtle effects upon the hydrology of the watersned system a considerable degree of precision was required. Computer program HEC-1 provided the foundation for this screening model. This program was utilized in the "multi-plan" (JOPER = 5) mode. Flood hydrographs for each subarea were simulated for future conditions. In the multi-plan mode the HEC-1 program simulates the occurrence of 8 ratios of the flood hydrographs as storms over the watershed, covering the full range of probabilty ratios from .99 to the Standard Project Storm level. These storm ratio hydrographs are computed for each subarea and combined and/or routed through every reach of stream in the system. In each reach of stream where improvement alternatives could be considered, a "damage center" was designated. Flood damage was computed for each of the "subreaches" determined by the location of each of the approximately 700 cross sections of the HEC-2 hydraulic model. These subreach damages were then aggregated to the damage center by summation along frequency profiles. This technique prevented any error which might have been caused by assumption of parallel profiles and preserved the effects of bridge backwater. This procedure was implemented by a version of the "St. Louis District Urban Damage Program." Two or more plans of improvement may be simulated in each HEC-1 computer "run." The output from the multi-plan model consists of discharge hydrographs at each subarea, combining station, and routing station, flood damages derived from peak discharges, and average annual damage at each economic damage center. The first plan in each run was used to simulate the unimproved condition in order to provide calculation of economic benefits and as a check on the computations. Proposed improvements

to the watershed were simulated by the effect upon the following functions:

a. Discharge - Storage. The relationships of the volume of water stored in a channel or detention reach to the outflow discharge from that reach is the primary characteristic of detention and a necessary function for determination of the downstream effects of other alternatives.

b. Discharge - Probability. The so-called "frequency" curve is the basis for damage calculations. Since the multi-plan model attributes a frequency to each ratio storm at a damage center, based upon the unimproved frequency curve at that damage center, the frequency curve at a center automatically compensates for the effects of upstream modifications.

c. Discharge - Damage. The relationship of flood stage to damage determines the amount of damage for a given peak flow at a damage center. The relationship of damage to discharge, rather than stage, is used in HEC-1 to include the effects of changes in the stage-discharge (rating) curve. This function is effected by all modifications such as channel improvements which alter the rating curve at a point.

26. In order to develop the necessary storage and damage functions for the full range of alternative measures the Maline Creek basin was subdivided into 52 routing reaches (PLATE D-75) further categorized into:

a. Detention Reaches. Fifteen routing reaches in the HEC-1 input data simulated the sites of detention reservoirs. It was assumed that each site would be dry detention with a low level outlet functionally similar to a highway culvert and an emergency

spillway with invert elevation 5 feet below dam crest elevation. A data base was developed for each site consisting of storage-outflow functions for each combination of 3 feasible dam heights and 9 feasible outlet sizes for a total of 27 combinations at each site. Outlet sizes 1-9 correspond to pipe diameters of 2, 3, 4, 4.5, 5, 5.5, 6, 7 and 8 feet, respectively. Outlet rating was based upon culvert hydraulics for pipes and weir flow for spillways. Storage rating was based upon available topographic maps.

b. Channel Routing Reaches. The remaining 37 reaches simulated channel routings using the "Modified Puls" method. The hydrologic discharge-storage function for each reach described the channel or overbank modification to that reach. In all but 6 of these reaches (designated "Non-Formulation") the discharge-damage function could be varied to simulate changes in rating curves and damage elevations. The "Non-Formulation" reaches were designated either in upstream areas without significant flood damage or at the mouth of tributary streams where backwater controlled the rating curve and no channel type improvement could alter the rating curve. A data base for alternative screening was developed for each of the 31 formulation reaches for the alternatives of channel improvements, bridge modifications, the combination of channel improvements and bridge modifications, and the clear and snag alternative as follows:

(1) Channel Improvements. Channel modifications were hypothethized as variable in size, shape and lining material. Four arbitrary bottom widths were selected for the size variable; large, medium, small and extra small. Sizes were held constant for hydrologically similar stream reaches. The small size was essentially the same channel cross section area as the existing channel. The large size was the largest width which could be accommodated without extensive relocations. Medium was selected as a reasonable width between large and small. Extra-small represented

a slight reduction of channel area to accommodate constructon within the existing channel. Two shapes were utilized; Trapezoidal with 3H to 1V side slopes and "U-frame" with essentially vertical walls. There were three types of lining considered due to the difference in roughness: smooth concrete (Mannings N = .013); Rock-filled gabions (N = .036); and grass lined earth (N = .046). In all cases the invert elevation was assumed unchanged from existing. This was required since, in many areas, storm sewers are located in the creek bottom. Preliminary cost estimates indicated that replacement of these trunk sewers was prohibitively expensive. Eliminating unreasonable combinations such as "U-frame" grassed channels led to 12 alternate channel descriptions for each reach. These were designated by type and size (C, G, E for type; L, M, S, X for size). Any size/type combination could be simulated in any formulation reach. The storage - discharge and damage - discharge functions for each reach and alternative were computed using 12 runs of the HEC-2 hydraulic model using the channel improvement option to simulate the channel excavation and roughness parameters of the modified cross sections. The existing bridge geometric were not altered.

(2) Bridge Improvements. Channel reaches were selected so that all major bridges were located at the lower end of a routing reach. Some few minor structures (designated "embedded") are located in the middle portion of a routing reach and were assumed to be replaced or modified should the channel be modified. In the majority case, however, the effects of bridge modifications can be assessed by changes in the storage curve of the upstream routing reach. Since bridge modification generally requires complete replacement of the bridge it was assumed that the replacement would be hydraulically designed to cause essentially no swellhead. One run of the HEC-2 program with bridge descriptions replaced by channel sections equivalent to that existing nearby provided the

storage and damage functions for the data base (designated FWN). Since bridge modifications are frequently complementary to upstream channel modifications the joint effects of these two modifications were added to the data base by 12 additional runs of HEC-2 with both bridge and channel modifications. These 12 runs were designated by the channel modification identifier and the suffix "N" as opposed to "B" for those without bridge modification.

(3) Selective Clearing. This alternative alters the rating curve at a station and was simulated by one run of HEC-2 with all roughness coefficients reduced 25 percent (designated RNB). It was considered unlikely that this alternative would be combined with bridge modifications.

(4) Low Level Flood Protectors and Sewer Modifications. It proved to be unnecessary to simulate storage and damage functions for this alternative since the sole effect is assumed to be a truncation of the lower end of the damage function. Flood protectors were alined primarily beyond the lateral boundary of the regulatory floodway and as far from the stream bank as possible. These protectors are only required in isolated areas, supporting the assumption that they would eliminate only a negligible portion of the flood plain storage. These measures were simulated by simple truncation of the damage function to the level of any of the 8 hydrograph ratios. This alternative could be applied in conjunction with any of the other 26 channel modification alternatives. It was normally applied in conjunction with the clear and snag alternative. Sewer modifications were assumed to have no effect upon the simulated hydrologic system.

(5) Property Aquisition and Relocations. These alternatives were assumed to have little tangible significance to the hydrologic analysis. Intangible aspects are discussed with the hydraulic design of the detailed plans. The economic impacts are discussed in APPENDIX B.

27. The subdivision of reaches adopted for this formulation effort allowed any combination of the 27 detention, 26 channel, and 8 truncation alternatives to be simulated in any of the 15 detention and 31 channel formulation reaches with only minor further assumptions or errors. Because the number of discrete alternative plans extends into the millions (including many unreasonable, unjustified, and irrational plans) and because of the non-linear functional relationships, the potential use of numerical optimization to reach an "NED" plan was rejected in favor of a screening process.

28. As a result of the extensive array of both competitive and complementary alternatives, and in view of the intractability of hydrologic and hydraulic parameters, (e.g., stage, discharge, and storage) the tangible performance of individual plans and alternatives were best evaluated in terms of the estimated damages caused by flooding. The displays of hydrologic and hydraulic data presented in this appendix were developed subsequent to formulation modeling. A special computer program was developed for management of the extensive data base, simulation of the hydrology and economics, and summarization of economic performance. This simulation model allowed the rapid assessment of 515 plans of improvement composed of combinations of reach/improvement alternatives. The methods and strategy employed in formulation of alternative plans is covered in APPENDIX B.

Results and Observations

29. The ultimate result of the plan formulation hydrology was the development of plans of improvements which conform to the objectives and constraints of hydrologic and hydraulic engineering and maximize higher level objectives of Environmental Quality, Regional Development, Social Well-Being, and National Economic Development.

These higher level objectives are largely beyond the scope of this appendix and are evaluated elsewhere in this report. The result of hydrologic plan formulation was the preparation of plans which satisfy the objectives and constraints stated earlier. The hydraulic performance of the detailed plans emanating from "cycle four" of the plan formulation process (see APPENDIX B) are presented later in this appendix. The following observations resulted from the plan formulation modeling process and provided a basis for the evolution of the detailed plans.

a. Detention Reservoirs. This alternative proved to be of only limited value for flood damage reduction. The number and location of potential sites are circumscribed by urban development. Very few of the available site/size combinations are economically justified. Some site/size combinations would be counterproductive since they would increase net damages. Those site/size combinations which are justified on a "first added" formulation basis remained justifiable as other measures were added to the hydrologic system. The optimum size for these dams generally proved to be the highest physically feasible dam coupled with a very small outlet. Many of the benefits of detention reservoirs remained unquantified in this economic analysis. These sites should provide:

(1) Water quality benefits by settlement and collection of "first flush" urban runoff, debris, and sediment.

(2) A net positive contribution to the endemic stream bank erosion problem of this watershed by significantly reducing and regulating the runoff hydrographs from storms of common frequency and magnitude. Since the justifiable sites are located in the extreme headwaters of the basin, the channels immediately downstream have been or are proposed to be paved and/or inclosed by local interests. Thus no significant problem is forseen with "clear water scour" immediately below the dams.

(3) No economic benefits in reaches below [illegible] above the 800 cfs point of Federal interest. [illegible] not estimated until well below that point. Thus, [illegible] benefits remain unquantified in those areas [illegible] dam where dams are most effective.

(4) A substantial reduction of the cost of [illegible] operation, and maintenance of the drainage structures [illegible] by regulating the quality and quantity of flows.

Counter to these many positive aspects of detention [illegible] must be recalled that a risk of catastrophic [illegible] introduced into an area where none existed previously. [illegible] would be minimized substantially by the location of the [illegible] structures and the nature of large storms in the region. [illegible] should be further minimized by careful engineering and [illegible] sound local assurances of adequate maintenance and [illegible] controls.

b. Channel Improvements. The examination of [illegible] improvement alternatives was the most extensive study [illegible] upon the initial impression that such modifications were [illegible] likely solution to the flooding problems within Maline [illegible] must be noted that as additional plans were formulated [illegible] formulation cycle, a decreasing reliance was placed upon [illegible] improvements. This is largely explained by the negative aspects [illegible] associated induced damages and by the effectiveness [illegible] truncation alternative introduced during "cycle four" [illegible] APPENDIX B) in reducing estimated construction costs [illegible] providing a high level of protection. It is interesting [illegible] that in a watershed as densely developed as Maline Creek [illegible] common examples of development of damageable property at [illegible]

elevations, channel improvements were rarely economically justifiable. This observation is explained by these factors: (1) construction cost estimates are very high and increase sharply when necessary to provide small additional increments of flood control benefits and levels of protection; and (2) a "domino effect" would occur by which upstream channel improvements would cause higher flows in shorter times. This would induce downstream damage and thus require modifications to downstream reaches.

Of the channel alternatives examined, the following general conclusions could be reached from the formulation modeling:

(1) Very Small Sizes. Ineffective.

(2) Gabion Linings. Not cost effective.

(3) Medium and Small Grassed Earth Channels. Overall these were the most effective channel types and sizes. Minimum induced downstream damages.

(4) Concrete Lining. Only justifiable in a few reaches and sizes. Grassed earth channels in combination with truncation proved more cost effective. Poorly formulated plans relying upon this alternative displayed extensive induced damage.

(5) Covered Channels. Similar performance to open channels, particularly "U-frame" types. Since costs are obviously higher, no net NED benefit is possible.

Thus, it is concluded that no plan relying exclusively upon channel and detention alternatives provided both an adequate level of protection and a economically justifiable project in the Maline Creek basin.

c. Bridge Modifications. The formulation modeling indicated that the bridge modification alternative was generally less desirable than channel modifications in terms of satisfying the objectives. Since many of the bridges in the basin are unable to pass moderately rare flows without significant backwater ponding, their performance in the simulation model was conversely similar to the detention dams. The positive benefits of reduced upstream ponding are counteracted generally by increased flows and induced damage downstream. In some cases, additional increments of protection are justifiable in downstream areas.

d. Low Level Flood Protectors and Sewer Modifications. Since these alternatives are assumed basically to be damage reduction effective, and their resultant hydrologic effects assumed to be inconsequential, their performance in the formulation model was predictable (e.g., minimum cost, satisfactory level of protection, and readily justifiable).

e. Selective Clearing. This alternative was frequently employed in the formulation planning in conjunction with the truncation alternative. It would be neither significantly beneficial nor detrimental on its own merits. It would be effective in counterbalancing the adverse effects of upstream improvements.

f. Combination Effects. It was anticipated, prior to formulation modeling, that certain combinations of reach/measure alternatives might provide complementary or synergistic effects. For example, a detention dam on one branch of the creek combined with a concrete channel improvement on an adjoining branch might well provide greater damage reduction downstream of the branch junction that the simple effects of the two alternatives acting separately. This possible effect was attributed to alterations of the timing of hydrographs. Contrary to the expectation, such

synergism was not apparent or significant in any of the model output. The sensitivity of the model to such factors is apparent in the displays of this appendix. It only can be concluded that "synergism" is not a significant factor in positive satisfaction of the study objectives. In a negative sense, however, a plan of upstream alternatives which decreases the available storage, improves conveyance, and accelerates the velocities, such as concrete channels with bridge modifications, can combine to increase downstream peak discharges by 50-100 percent. Such increases are obviously damaging. Efforts to alleviate these downstream consequences by further channel modification founder upon the cost and environmental factors associated with extremely large channels.

g. Level of Protection. The selected plan emanating from the fourth cycle of formulation detailed in the following section, provides one of the highest levels of protection of any plan investigated, including many with extremely large and costly alternatives. The use of high levees in this basin was rejected primarily because of the impossibility of operating closure structures at the many road crossings within the time frame allowed by flash flooding. The cost of replacing or modifying bridges was prohibitive. Plans which approached a 1 percent probability level of protection were economically unjustified. None of the plans or alternatives considered physically feasible could approach the Standard Project Flood level of damage protection.

Summary

30. The plan formulation phase of this study successfully concluded with the selection of a plan of improvements which satisfies the tangible performance criteria. This plan was verified, subjected to more detailed hydraulic design, and further evaluated for its

intangible and unquantified impacts, is documented in the following section. It is likely that many other similar plans would also achieve the objectives. Refinement [illegible] selected plan is, however, left for the more detailed phase of post-formulation design. The selected plan, as formulated, meets the general purposes of this study - to demonstrate an economically justifiable and physically feasible solution to the flood control problems of Maline Creek.

31. A major element in the formulation process was the use of a detailed hydrologic/economic computer simulation model. The alternatives postulated are believed to be a comprehensive set of feasible solutions. The development of a comprehensive analytical solution to this formulation problem would be impossible without the use of the computer model. There is a great deal of confidence that the selected plan will perform as predicted by the model without unanticipated adverse effects. It must be mentioned that general observations noted in this section are applicable only to Maline Creek, however, they bear considerable similarity to the findings of other similar studies. The level of detail of the basic data utilized in this formulation is considered to be adequate to support the conclusions. A higher level of detail is necessary for post-authorization design.

HYDRAULIC DESIGN OF THE DETAILED PLANS

Objectives

32. This final phase of the fourth cycle (see APPENDIX B) was directed toward:

a. Hydraulic design of the plans selected for detailed consideration.

b. Verification of the hydrologic/hydraulic performance predicted by formulation planning.

c. Evaluation of intangible and unquantified aspects of the detailed plans.

Scope.

33. The hydraulic design and performance of four plans of improvement are discussed in more detail in this section. They are the selected plan, the NED plan, a "traditional plan," and the cycle three "conventional" plan.

a. The Selected Plan. The plan of improvements providing the "best" compromise of NED, EQ, RD, SWB features was selected. The plan thus selected was the EQ alternative.

b. The NED Plan. The plan which maximizes National Economic Development is the NED plan. The NED plan has the same flood control components as the selected plan except for the omission of grass-lined earth channel improvements in the reaches ending at mileposts 4425 and 5685. Reaches are designated by the milepost at the lower end of the reach. For brevity, this plan is not

specifically detailed. The hydrologic/hydraulic performance is substantially the same as the selected plan. Other distinctions are documented elsewhere in the report.

c. The EQ Plan. The plan which maximizes contributions to the Environmental Quality objectives was the EQ plan. This is the plan selected for recommendation.

d. The "Traditional Plan." This plan is presented in more detail as an example of traditional methods of solving urban flood control problems. It is not proposed for construction because of its poor economic feasibility, but is presented for contrast and comparison with the selected plan. Its objective is to develop a similar level of protection to the selected plan but without the complex plan formulation efforts. This plan was formulated entirely upon hydraulic/hydrologic criteria without the use of economic benefit/cost data and extensive plan formulation techniques. The objective was to reduce the 10 percent chance flood levels to bankful or below stages, including the downstream effects of upstream improvements, via channel and bridge modifications. Detention reservoirs were not used since, on a traditional engineering basis, their hydrologic/hydraulic effects appear to be negligible. Since concrete-lined channels were required in some upstream reaches to provide the objective level of protection, the resulting high downstream velocities and discharges required the uniform use of concrete lining in all reaches in order to prevent excessive scour and erosion. Other alternative management measures were thus foreclosed. Bridges were modified in order to provide equal cross sectional area to the upstream channel modification. It is assumed that local interests would provide the necessary sewer modifications required to pass bankful stages without damage.

e. The "Conventional" Plan. The low level flood protectors incorporated into the selected plan represent a new concept in urban flood control for the Corps. Since the recommended plan contains this unconventional and potentially unacceptable component, an additional plan was carried forward from "Cycle 3." This plan may also be referenced in other sections as the "Cycle 3" plan. This plan is considered to be "conventional" in regard to the flood control measures employed. That is, a conventional mixture of detention dams and channel modifications were the primary flood control management measures proposed. The Cycle 3 draft recommended "conventional" plan was carried forward in order to display the comprehensive diversity of alternatives considered.

34. Design Criteria and Rationale of the Selected Plan. The hydraulic phase of this study was directed toward the objectives previously stated and was required to develop a practical set of improvements which provide the same level of performance as the proposed selected plan. In order to meet these purposes, the following steps were taken to ensure engineering feasibility and appropriate cost estimates for the detailed selected plan:

a. Detention Reservoirs. Reexamination of spillway and outlet sizes, lengths and elevations. As a result of the level of detail of the overall plan and in consideration of the adequacy of available information, only a general assessment of the spillway adequacy relative to the spillway design flood was attempted. Dams at the sites selected are considered capable of safely containing and/or passing a flood of Probable Maximum magnitude (PMF). The PMF is normally assumed to be preceeded, by 5 days, by a Standard Project Flood. PMF is defined as the flood that may be expected from the most severe combination of critical meteorological and hydrologic conditions that are reasonably possible in the region. The Standard Project Storm, as previously discussed herein, is

generally 40-60 percent of the magnitude of the PMF. It is considered feasible, at the sites selected, to provide a combination low level and emergency spillway capacity sufficient to provide 3-4 feet of freeboard, above the maximum pool elevation of the design storm. This will essentially eliminate any reasonable prossibility of overtopping of the earth embankment during extreme storm conditions. The reservoir designs are considered adequate to provide cost estimates for purposes of this report. These designs are illustrated in APPENDIX E.

b. Channel Modifications. Sizes and locations of channel improvements were based upon the "cycle four" proposed selected plan. Transition sections were designed at changes of channel cross section, bridges, and tributary junctions. Roughness values (Mannings "N") were reevaluated on a reach specific basis. In view of the unstable soils of the watershed and in recognition of the mildly increased velocities of the improved channels, grade control structures (APPENDIX E) are included in the design at approximately 1/4 mile intervals in all reaches of the project. Paving of bridge inverts is considered a suitable substitute.

Some of these grade control devices are combined with aquatic habitat structures (APPENDIX F) in fulfillment of the EQ aspects of the plan.

c. Low Level Flood Protectors. The effective top of the low level flood protectors is set at the level of the 10 percent probability flood, future conditions with project. Establishing this low level frequency target goal allows consideration of very small sized flood walls and/or levees. In general, a maximum 3 foot height was sought for a number of reasons. For example, the low level of protection would eliminate any possibility of severe impacts when overtopped; no hazzard would ensue due to interior

impoundment; interior drainage would be essentially instantaneous (i.e., a matter of minutes or possibly hours at most); the tops of low flood walls could be designed to provide seating for the public using the trial system and enjoying the preserved open space; and scenic vista's would be minimally impacted.

One area of some concern is freeboard needs appropriate for low level flood protection. Freeboard is the technical engineering term for extra height to insure performance at the target level, accouting for such things as potential wave wash and uncertainties in height determining calculations. It should be observed that if equivalent flood protection were provided via a channel improvement, no freeboard factor would be included, thus levees and floodwalls normally are required to have an extra conservative margin of safety. The specification of the freeboard detailed criteria has been deferred to the more detailed analysis appropriate to post authorization studies based upon the following rationale:

(1) It was hypothesized that a maximum flood protector height would be no more than 3 feet high. The physical location of this low level protection would be far enough back from the streambank so as to provide assured positive protection from the 10 percent probability flood, without creating a "safety trap" for flood levels exceeding the level of protection. Any failure resulting from overtopping, and/or structural failure of a 3-foot high flood protector though unlikely and improbable in the light of the possible durations of flooding, would most certainly not be considered catastrophic. Flood protectors must be designed such that overtopping, particularly by wind-induced waves, does not degrade the profile and/or significantly erode the structure. Given the non-erodable crest and the minimum potential wind fetch and the very short duration of a flood of the 10% chance magnitude at the protector crest, freeboard for wave protection becomes an

essentially negligible factor. More detailed studies during the post-authorization phase will verify/modify the negligible need for wave wash freeboard, so as to further insure positive protection from the 10 percent chance flood.

(2) Based upon the hydraulic sensitivity tests previously described, and the debris characteristics of the Maline Creek basin, the most probable mode of flood protector overtopping is by backwater ponding from downstream bridges. Any back water flooding that might possibly occur would most probably be caused by debris obstruction at bridges (PLATE D-74). Overtopping from this source negatates hazards resulting from high velocity flows. Other features of the selected plan, and the required local maintenance assurances, should minimize debris problems.

(3) Provision of extensive amounts of freeboard would aggravate the "safety trap" aspect without an attendant increase in the nominal degree of protection. All of the normal reasons for provision of freeboard in larger river systems, and designs for higher levels of protection, are either (a) not applicable to the Maline Creek situation, or (b) amenable to inclusion in the detailed hydraulic design of the total system. For example, a 20 foot high Mississippi River Urban levee would be properly provided with 3 feet of freeboard to safeguard against wave wash, uncertainties in the frequency and other analyses. A simple proportion indicates 15 percent of the height is freeboard. On a maximum 3 foot levee system, a maximum of 5-6 inches could be freeboard. The proration technique is crude, and actually less than 15 percent may be applicable to low level protection. The level of detail pursued in a feasibility report cannot properly address such relatively detailed concerns. The freeboard issue and its determination, is most appropriately deferred to the more detailed post-authorization studies.

(4) The ground elevations at the base of the low level flood protectors become a variable of considerable significance with the constraint that total height generally not exceed 3 feet. These elevations will be carefully determined in the post-authorization design and are not now known factors.

In order to minimize conflicts with the National Flood Insurance Program, the lateral alinement of the low level flood protectors is based upon a location as distant from the creek bank as possible without relocating structures, and beyond the location of the regulatory floodway, based upon the 1 percent probability flood. Selective clearing and other devices are used in the selected plan in those few cases where minimum setback objectives could not be met, in order to minimize the induced swellhead. Bank protection is provided at those protected locations where flows could impinge.

d. Sewer Modifications. Modifications of storm sewer outlets into Maline Creek are required to provide the desired effect of damage curve truncation. This effect is considered to be produced primarily by the addition of "flap gates," or similar devices to prevent flood damage by sewer back-up from the creek. Other alterations such as raising manholes or sewer diversions to lower areas are preferable wherever possible. Flap gates, or similar devices, must be designed to remain open during a flood until the stage at the outflow point rises to a level corresponding to the beginning of damage in the tributary watershed. In areas provided with low level flood protection, this "gate closing stage" should correspond to the elevation of the bottom of the berm. In areas with low level flood protection, this interior flood control system configuration will function only for local runoff of impounded water at stages below the bottom of flood protection and for both local runoff and any sewer surcharge for those stages in the 3-foot range between the bottom and top of low level flood protection.

e. Interior Flood Control. The interior flood control aspect of areas provided with low level flood protection is considered to be provided for by addition of a system of collector ditches and gravity sewers. A system of collector swales or gutters is preferable, considering debris collection, to drop inlets and collection pipes, although the latter may be necessary in situations of limited right-of-way. Although each of the 30 individual low level flood protected areas would require detailed analysis at a later stage of design, an analysis and general description of the conceptual system has been made. Such a system could include swales, or catch basins and collection pipes, and a long run of outfall pipe, without flap gate. Details of the topgography and hydrologic/hydraulic characteristics of potential protected areas are currently under study. Individual protected areas are identified on PLATES D-102 to D-113. As a result of the sensitivity of base data utilized in this report, it must be understood that much of the topographic data and resultant conclusions will be revised with more detailed levels of engineering design. This material is only considered to be adequate for the purpose of cost and feasibility conclusions. As a result of the swellhead created by bridges it should be possible, in many cases, to terminate the outfall pipes immediately below the nearest downstream bridge. Considering that the maximum head encountered would be 3 feet and with blocked drainage for only 1-2 hours typically, use of a very smooth pipe would allow gravity drainage under head by the difference in energy grades between the pipe and the creek. Outfall pipes are currently sized based on field inspection, storm sewer sizes serving nearby areas, and engineering judgment. Interior flood control appurtenances required for various combinations of design storms on the leveed area coincident with various stages in Maline Creek are being sized for economics and cost analysis. The recommended sizes to be included in the final survey report should eliminate a majority to all of the induced damages occuring landward

of the low level protectors. These features will be only roughly sized in this report. In the detailed design phase (pre-construction planning), detailed hydrologic analysis and hydraulic design computations will be performed at each of the sites proposed for low level protectors. While sizes and lengths of outfall pipes may be modified (or a substitution of means for removal of interior water), no signficant changes to costs and benefits would be expected. The eventual adopted design criteria should eliminate most or all of the induced damage from extremely localized storm events of reasonable magnitude. It should be noted that any potential induced damages would be limited to a band of elevations approximately 3 feet high, since the low level flood protection would be overtopped from the landward side if design conditions are drastically exceeded.

f. Selective Clearing. The stream channel and overbank areas for 50-100 feet on either side of the banks would be cleared of trash, brush, weeds and small trees. Grass sod must be maintained to prevent erosion and sediment problems. The effect of selective clearing is reduction of the roughness coefficients. This alternative was foregone in several reaches in support of environmental quality objectives.

g. Bridge Modifications. Bridges noted for replacement would be replaced by a structure capable of passing a large design flood with no appreciable swellhead or probability of failure by erosion.

h. Bridge Removal. The removal of an abandoned aquaduct bridge (approximate milepost 300) was selected after considerable study of alternatives to mitigate the adverse effects of upstream improvements in the lower reach of Maline Creek from mileposts 490 to 1104. The replacement of an additional aquaduct near the same location would provide additional relief, but at considerable expense.

Methods

35. In order to achieve the objectives of the hydr[illegible] phase, the design alternatives were simulated by using [illegible] of the alternatives affecting streamflow according to [illegible] of the preceding paragraph, were encoded to computer pro[illegible]. This program produced water surface profiles for a [illegible] discharges corresponding to the future, without-project condi[illegible]. The storage-discharge rating tables from this HEC-2 run [illegible] to the HEC-1 hydrologic model (JOPER = 5) to develop a fina[illegible] modified discharges for all ratioed floods. The program HEC-2 was then recycled with the final peak discharge set to produce the water surface profiles for the selected plan, as displayed in PLATES [illegible] through D-101. Flooded area maps were also determined on the basis of this set of profiles (PLATES D-102 through D-113). It must be noted that the profiles and maps displayed are based upon discharge ratios which are slightly higher than the true expected frequencies. This is due to the lack of depth-area rainfall adjustment when utilizing the program HEC-1 in the multi-plan (JOPER = 5) mode. The Standard Project Storm also required slightly different rainfall distribution. In order to overcome these minor differences, the program HEC-1 was utilized in the "depth-area stream system" mode (JOPER = 4) to calculate frequency curves (PLATES D-117 through D-135) and discharge hydrographs (PLATES D-136 through D-164) for the selected plan. The discharge hydrograph set provided the basis for the stage hydrographs (PLATES D-165 through D-188) utilized in combination with the appropriate HEC-2 stage-discharge rating. Stage hydrographs include rises produced by backwater [illegible] reverse flows from downstream stations. As a final check to [illegible] the accuracy of the computed hydraulic water surface profiles [illegible] all plans, an investigation was conducted in May 1980 to verify the bridge swellheads. The bridges with the largest swellheads were

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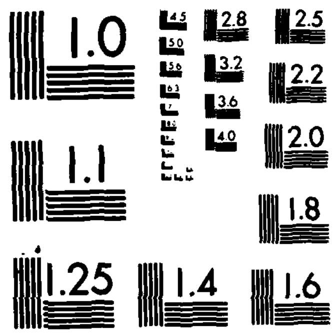

MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

reviewed and field checked. Only the bridges at Dunn Road/I-270 (MD mile 2.8) and Berwyn Drive (MC mile 0.5) were found to be significantly in error or not representative of present (1980) conditions. All profiles for the standard project flood at the Dunn Road bridge were recomputed and adjusted reflected on PLATES D-46, D-96, D-220, D-333. The Berwyn Drive bridge has been supplemented downstream by a culvert. No adjustments were considered justifiable at Berwyn Drive.

Verification

36. On April 11, 1979 a storm of considerable similarity to the design storm occurred in the St. Louis metropolitan area. Extensive rainfall and highwater data were collected. An isohyetal map is presented in PLATE D-8. Appropriate rainfall hyetographs are shown in PLATES D-189 through D-193. Highwater marks are illustrated on the water surface profiles (PLATES D-5 through D-16). Utilizing the hydrologic model (HEC-1, JOPER = 3) discharge hydrographs (PLATES D-194 through D-202) were computed for future conditions with and without the selected plan. Only the third burst of rainfall was simulated, with base flow and the loss rate parameters, STRKR and DLTKR, adjusted to a level appropriate to a 10 percent probability flood. Utilizing HEC-2 rating curves, the recorded peak discharges were reproduced within ± 10 percent throughout the basin. Stage hydrographs for the simulated flood are attached as PLATES 203 through 213. These computations served to verify the hydraulic performance of the selected plan including design refinements. Brief calculation of economic damages, based upon the final profile set, verified the flood damage performance of the selected plan.

Evaluation of the Selected Plan

37. The physical attributes of the selected plan are best expressed by the plates of APPENDIX E, and the hydraulic performance, as compared to the without condition, by the plates of this appendix. All that remains is a discussion of the intangible and unquantified aspects.

a. Degree of Protection. The plan provides a minimum 10 percent probability level of protection in improved stream reaches. Many areas and reaches exceed this level of protection. Many factors of the analysis from the areas of hydrology, meteorology and economics, too numerous to repeat here, combine to make this a safely conservative estimate. Because the low level flood protection will be designed to prevent erosion by overtopping, some measure of damage reduction may be achieved for floods only slightly in excess of the level of protection.

b. Standard Project Flood. No plan formulated could provide absolute protection against the SPF or even a flood of the 1 percent probability flood magnitude. The selected plan reduces damages from such an event by a significant amount. From a public safety point of view, the most significant positive contribution is the acquisition and control of the 10 percent probability flood plain. Relocation of buildings located as to impede construction of the project, also has the positive impact of limiting public access to the area of high risk due to high velocities. The low level flood protectors, by their physical presence, should result in public awareness of the extent of relatively frequent flooding. The public occasionally must be reminded of the design level of protection.

c. Channel Stability. It must be recalled that channel stability was the primary water resource problem identified by the public in regard to Maline Creek. Although direct resolution of this problem is beyond the Federal interest, and an analytical

solution remains largely beyond the state of the hydrologic art, the selected plan provides many positive contributions such as reservoir regulation of very frequent events, bank stabilization, bottom control structures and property acquistion. The only negative factor is the mildly stimulated velocities and discharges produced by the channel improvements. These are considered to be ameliorable by proper engineering of the system and its components, and by post-construction maintenance. Maline Creek must be considered a rapidly degrading stream, from an erosion standpoint, in its existing condition. The clay loessial soil in its undisturbed state is highly subject to stream bank caving. Based upon the suggested maximum permissible channel velocities of EM 1110 2-1601 (July 1970) it has been estimated that this soil, when protected by suitable vegetation, reshaped and compacted in the improved channel reaches, will sustain the erosional velocities of frequent flooding. Further investigation for omission of extensive bank protection stems from consideration of the consequences of potential bridge blockage should the protection collapse during a flood event. Operation and maintenance cost estimates include the repair of minor erosion areas due to major floods. No difficulty with soil sedimentation in channels has been experienced or is anticipated. In the interest of reducing construction costs, and of insuring the integrity of insolated protected areas the erosion and sedimentation characteristics of the channels should be thoroughly tested in the post-authorization design.

d. Interior Flood Control. In order to provide the desired uniform level of protection, the selected plan included 8.36 miles of low level flood berms. This represents 16 percent of the total stream mileage in the selected plan. No berms were provided for areas with less than 10 percent probability of flooding. The inclusion of the low level flood protectors introduces an interior flood control problem to the urban environment. Simply stated, for

probabilities not exceeding once in every 10 years on the average, for a maximum predictable period of a few hours, interior runoff from very small isolated areas may coincide with blocked drainage due to high creek stages. Since the times of concentration of the interior and of the creek at the line of protection are vastly different, and since both sources are only strongly responsive to high intensity rainfall, the chance of significant coincidence is slight. The consequences of exceeding the level of protection from either source is essentially unchanged from that existing. A possibility exists that the design capacity of the storm sewer system could be exceeded by very high intensity, short duration rainfall without coincidental exceedence of the level of protection of the low level berms. The excess runoff could then be impounded behind the berm causing induced damages. This situation is under study and may result in provision of additional hydraulic capacity in the interior flood control system to accommodate the surcharge runoff from the contributing drainage area or to otherwise detain or divert the surcharge runoff. The known storm characteristics of the area and the very small drainage areas involved, make the induced damage by sewer surcharge situation highly improbable. It must also be noted that the design frequency of the storm sewers ($15\pm$ year recurrence interval) exceeds the design level (10-year recurrence interval) of the low level protectors. The interior flood control problem, however, will be carefully studied in the pre-construction planning phase. No pumping is expected to be necessary.

e. Bridges. The predicted hydraulic performance of this plan is dependent upon many of the 62 existing bridges within the routing reaches of the watershed providing a storage routing, or "metering" function. In the future condition, any enlargement of bridge openings, reduction of road profiles, or upstream encroachment by landfill or urbanization would be generally undesirable. Conversely, contraction of bridge openings, increases in road

profiles and exclusion of upstream flood plain development should be generally beneficial. In general, the long-term hydraulic performance of this plan is dependent upon regulation of flood plain development and bridge modifications. The plan can be expected to be generally insensitive to development within the hydrologic subbasins. An instutitional arrangement to determine the system-wide impacts of proposed modifications to the floodways of the creeks may be required. Very large and rare floods, such as the standard project flood, could be expected to cause some failures of bridges and their embankments both with and without the proposed plan. In an intangible sense, the selected plan provides some mitigation of the probability of bridge failures by:

(1) A general reduction of flood heights and discharges within the channels. Velocities are only mildly stimulated.

(2) A reduction in potential debris blockage related to acquisition and maintenance of most flood plains.

(3) Conservative hydraulic design of new and modified bridges with the objective of provided protection against the erosive forces of the standard project flood.

(4) Modification of existing bridges to achieve the above objective consistent with the necessity to provide stable channels.

f. Functional Operation. No component of the system would require operational decisions to perform its function. The system would be self-regulated. Routine maintenance such as minor repair and grass cutting would be performed by the local sponsors, subject to government assurances. Neglect of normal maintenance could significantly reduce the performance of the project and/or endanger public safety.

Evaluation of the Traditional Plan

38. The physical attributes of the traditional plan are shown in the plates of APPENDIX E. The comparison of the hydraulic performance to the without project condition is shown in the plates of this appendix. All that remains is a discussion of the intangible and unquantified aspects.

a. Degree of Protection. This plan provides a minimum level of protection against the 10 percent probability flood. In order to maintain a fairly uniform channel shape, many areas and reaches exceed this level of protection. Although this plan will not provide complete protection against less frequent floods, it will lessen their severity. This can be seen by examining the water surface profiles (PLATES D-214 through D-225) and the flooded area maps (PLATES D-226 through D-237). The frequency curves (PLATES D-250 through D-268), discharge hydrographs (PLATES D-269 through D-296) and stage hydrographs (PLATES D-297 through D-325) show the effects of the traditional plan.

b. Standard Project Flood. No plan formulated could provide absolute protection against the SPF event or even a flood of major magnitude such as the 1 percent probability flood. However, the traditional plan will decrease the extent of flooding caused by these rare events.

c. Channel Stability. It must be recalled that channel stability was the primary water resource problem identified by the public in regard to Maline Creek. Although direct resolution of this problem is beyond the Federal interest, the traditional plan would greatly reduce channel erosion. With the installation of a concrete lined channel, erosion would be limited to overbanks which

would be protected against events of less than 10 percent probability. Although velocities in the channels would increase, this would not cause an erosion problem for the concrete lining.

d. Functional Operation. No components of this plan would require operational decisions. Routine maintenance such as minor repairs and channel clearing would be performed by the local sponsors, subject to Government assurance. Neglect of normal maintenance could significantly reduce the performance of the project and/or endanger public safety.

EVALUATION OF THE "CONVENTIONAL" PLAN

39. The "conventional" plan (i.e., plan 123) utilizes channel modifications and detention basins as flood control components with great similiarity to the other detailed plans. The channel modifications involve modifying the main channel from: reach M3 (mile 1.817) upstream to Lucas and Hunt Road (mile 3.800); reach M8 (mile 4.425 to West Florissant Avenue (mile 5.075)); reach M10 (mile 5.685) to north Hanley Road (mile 7.934); and reach MG2 (mile .487 to .821, Tributary MG). All modified reaches would have an trapazoidal grass lined earth cross section (3H on 1V side slopes) except for reaches M11, M12, and MG2, which would have a concrete lining. Reaches M11 and MG2 would have trapazoidal section, while M12 would be a U-frame configuration. TABLE D-10 presents a summary of the modified reaches' physical characteristics. PLATE D-327 shows a generalized plan view of the flood control components.

40. Working in conjunction with the channel modifications are 8 detention basins. These 8 detention basins are MD-1, MD2-2, MD1-1, MH-1, M22, M27, MF-1, and MF2 (see PLATE-327). They are designed to be dry under normal conditions. However, under storm conditions, they would capture and temporarily detain excess runoff and subsequently release the flood waters at an essentially non-damaging rate. The proposed dam heights, dam lengths, and storage capabilities for each site are presented in TABLE D-11.

41. The primary flood control accomplishment resulting from the implementation of the "conventional" plan would be a geographically widespread reduction in tangible average annual flood damages. This reduction in tangible damages is expected to be accompanied by intangible benefits, such as reduced social disruption, personal losses, flood risk, and, to some unquantifiable extent, a reduction

TABLE D-10
MALINE CREEK
CHANNEL MODIFICATION PHYSICAL CHARACTERISTICS
CYCLE THREE "CONVENTIONAL" ALTERNATIVE

Reach	Bottom Width (feet)	Top Width (feet)	Average Depth (feet)
M3	20	150	21.7
M4	20	155	22.5
M5	60	154	15.6
M6	60	145	14.1
M8	60	146	14.4
M10	90	123	16.4
M11	30	115	14.1
M12	45	47	11.3
M13	30	78	9.0
M14	30	92	10.3
MG2	15	76	10.2

in streambank erosion problems, as well as the recreational and environmental accomplishments discussed in other appendixes.

43. Flood height reductions for the cycle three "conventional" plan vary by location and flood frequency. However, reductions of from 3 to 6 feet for the higher numerical flood probabilities on the main channel reaches are common. The variations in flood stage reductions are best illustrated by the water surface profiles attached as PLATES D-328 to D-339.

44. Based upon the highwater marks and rainfall frequency data presented in Section C, the flood of record in the watershed, June 14-15, 1957, has a general recurrence probability of approximately 10 percent in any one year. It is estimated that average annual damages from a flood of that magnitude would be reduced 59 percent by implementation of the cycle three "conventional" plan of improvements. The occurrence of a storm of truly major magnitude and low recurrence probability (the Standard Project Flood), such as that which would have occurred had the 1957 storm been centered upon the Maline Creek watershed, or had the 1977 storm over Brush Creek in Kansas City, Missouri occurred over Maline Creek, would result in an approximate 11 percent reduction in average annual damages with the "conventional" plan of improvements. The hazards to public safety from the occurrence of such a storm would not be increased by the "conventional" plan. Instead, they would be substantially reduced by virtue of the land acquisitions required and the potential for controlled access to areas of high risks that result from high velocity flows at considerable depths.

45. As a result of the detention features of this plan as well as the channel enlargements, flow quantities and velocities generally would be reduced from those presently existing. The duration of

TABLE D-11
MALINE CREEK
DETENTION BASIN PHYSICAL CHARACTERISTICS
CYCLE THREE "CONVENTIONAL" ALTERNATIVE

Site	Dam Height (feet)	Dam Length (feet)	Active Storage (acre-feet)
M27	27	540	198
M22	24	415	88
MH-1	35	490	186
MF-1	35	515	270
MF-2	28	350	56
MD-1	17	485	52
MD1-1	24	350	125
MD2-2	24	510	95

flooding, a matter of only a few hours in any case, would not be substantially changed by the selected plan. The possibility for a catastrophic failure due to flooding is minimized by the "conventional" plan for the following reasons. There is:

a. No reliance upon physical barriers to floodings (i.e., levees/floodwalls/berms) or other low level flood protection;

b. Design criteria for detention dams; and

c. A lower chance of bridge failure due to debris blocking, as a result of better access for channel maintenance and controlled access by the public. The intangible aspects of bridges related to the selected plan are also applicable to the "conventional" plan.

MALINE CREEK, MISSOURI

SURVEY REPORT FOR FLOOD CONTROL
AND ALLIED PURPOSES

APPENDIX E

DESIGN AND COST ESTIMATES

APPENDIX E

DESIGN AND COST ESTIMATES

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DESIGN AND COST ESTIMATES

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DESIGN AND COST ESTIMATES

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APPENDIX E

DESIGN AND COST ESTIMATES

1. The design and cost estimates were prepared as the various plans were developed in each of the formulation cycles (see APPENDIX B). The design progressed from the conceptual, based on engineering judgment, to preliminary design based on refined engineering judgment and previous designs, and lastly to the survey report scope design. This survey report scope design is not as detailed as will be presented in the General Design Memorandum and subsequent reports.

CYCLES ONE AND TWO SUMMARY

2. The design and cost estimates analysis of Maline Creek was pursued via five cycles of formulation. These cycles of formulation progressed from very gross approximations through rather detailed analysis so as to obtain the recommended plan of improvements. The design and cost estimates used in the first two cycles of formulation was of a rather gross level of detail and are available for review if so desired as contained in the July 1973 and January 1974 draft Maline Creek survey reports. Some techniques used in the design and cost estimates are the use of designs and cost curves developed for previous projects which contain similar work; unit pricing; and actual design, quantification, and costing of project items. Careful review of those reports indicate that more detailed study of the area was warranted as summarized herein.

CYCLE THREE FORMULATION SUMMARY

3. Design and cost estimating support for the third cycle of formulation consisted basically of development and use of generalized "cost curve" data. This cost curve data was developed to reasonably approximate Maline Creek conditions based on the judgment of senior design engineers experienced in the problems and typical solutions of this urban area. The results of the cycle three design and cost estimating work for the 136 plans created during the third cycle of formulation are documented in the draft Maline Creek survey report dated March 1978. The cycle three draft recommended "conventional" plan of improvements as well as a nonstructural alternative were carried through the entire formulation process in order to display the comprehensive diversity of alternatives considered.

CYCLE FOUR FORMULATION SUMMARY

4. The fourth cycle of formulation was necessary in order to address the revised criteria discussed in APPENDIX B. Design and cost estimating support for the 374 plans developed in the fourth cycle of formulation plus the nonstructural plan, the cycle three "conventional" plan and an all channel plan was based on a refinement of the cost curve data developed in cycle three plus the addition of cost curves for the low level flood protectors. An NED, EQ and recommended plan of improvements was identified at the conclusion of the fourth cycle of formulation. The performance of the recommended plan without low level flood protectors was also presented. The systems of account display and environmental impact display present the no action alternative, NED plan impacts, cycle three "conventional" plan impacts and the EQ/recommended plan impacts.

Traditional Channel Plan

6. A 10-year level of protection plan was prepared based only on use of traditional channel improvement of flood control measures excluding the use of low level flood protectors. This plan is shown on PLATES E-1 through E-17. This plan consists of concrete-lined channels with vertical or inclined side slopes. It was found that only concrete-lined channels could provide the 10-year level flood protection objective and minimize stream bank erosion from the traditional practical structural management measures. A 10-year nonstructural plan was also tested and found to cause severe home relocation and other community disruptions. The concrete-lined channels vary in size from 100-foot bottom width in the lower reaches to 15-foot bottom width in the upper reaches. Typical concrete-lined channel cross sections are shown on PLATE E-42. In addition to the concrete-lined channels, 27 bridges were assumed removed and replaced. The bridge lengths range from 55 feet to 300 feet, and the width from 2 lanes (25 feet) to 4 lanes (50 feet). This alternative was comparably designed and costed on the basis of cost curve data. The first cost of construction was approximately $148,000,000. Due to this large cost no further consideration was appropriate for traditional channel improvement flood control alternatives.

Plan Without Flood Protectors

7. A plan was developed consisting of the cycle four recommended plan excluding low level flood protectors (see PLATES E-18 through E-29). This alternative was designed and costed on a comparable basis. This alternative has a first cost of construction of $32,200,000. A comparison of average annual costs to average annual benefits yielded a benefit to cost ratio below unity. Therefore, no further consideration was appropriate to the cycle four recommended plan excluding its low level flood protectors.

Nonstructural Plan

8. A completely nonstructural 10-year level of protection plan was prepared, consisting of complete relocation of the structures located in the 10-year flood plain area. In order to provide the maximum opportunity for this nonstructural solution to exhibit a favorable benefit to cost ratio, the relocation plan costs were limited to the entire 10-year flood plain area (about 90 percent of the average annual damages occur in the 10-year flood plain area). The details of this analysis are presented in APPENDIX B. The benefit to cost ratio of this alternative is 0.07. This alternative was so infeasible economically that it was eliminated from further consideration.

Cycle Three "Conventional" Plan

9. The draft recommended plan (i.e., plan 128) developed during the third cycle of formulation was updated and carried through the entire plan formulation process. The flood control features of the cycle three draft recommended "conventional" plan are shown in PLATES E-30 through E-37. This alternative was carried through the entire formulation process in order to display the comprehensive diversity of alternatives considered.

RECOMMENDED PLAN OF IMPROVEMENTS

10. The recommended plan of improvements developed during the fourth cycle of formulation was verified in the fifth cycle of formulation as being the best flood control, outdoor recreation and environmental quality mix. The recommended plan flood control features are channel modifications, low level flood protectors, and detention reservoirs. This plan is shown in PLATES E-38 through E-66. The channel modifications consist of inclined earth channels

with base or bottom widths varying from 2 feet to 85 feet. The low level flood protectors are concrete retaining walls designed to be stable and to resist scour under flooding conditions. In conjunction with these retaining walls, an interior drainage system designed to remove water trapped behind them was incorporated in the plan. There are eight detention reservoirs that work in conjunction with the other flood control features. They capture and impound storm water runoff and subsequently release this water at a rate that would be essentially nondamaging. Under normal conditions these reservoirs would be dry. Detention reservoir locations, embankment profiles and typical cross sections are shown in PLATES E-49 through E-57. The material used to construct the detention reservoir dam embankment will be obtained from on-site excavation. Material excavated from the channels will be used to fill local depressions or channel cutoffs within the project limits. Other construction materials will be purchased within the project basin.

Detailed Plan Design and Cost Estimate

10. The cost estimate of the selected plan (formulation cycle five) consistent with the President's guidelines for cost sharing is summarized in TABLE E-1 with details shown in TABLE E-2. The cost estimate of the selected plan, based on existing legislation and a price level of October 1979, is summarized in TABLE E-3. TABLES E-4 and E-5 provide information regarding the first costs of construction. The operation and maintenance costs assumed are as shown in TABLE E-6.

Public Safety Considerations

11. The design of the project components comply with all applicable EM's, codes, and regulations. It is felt that if the components fail there would be a negligible chance of injury or loss of life to citizens in the basin.

CONSTRUCTION COSTS

12. The following cost estimate is for all work included as part of the selected plan of improvements. Price level of the estimate is October 1979. TABLES E-1 and E-2 are a summary of the selected plan's costs based on the requirements of the President's proposed cost-sharing policy. TABLE E-3 is a summary of the selected plan's costs based on existing legislation. TABLES E-4 and E-5 present a more detailed breakdown for Federal and non-Federal construction costs, respectively, for the costs based on existing legislation.

TABLE E-1
MALINE CREEK
COST SUMMARY FOR THE PRESIDENT'S COST-SHARING POLICY

	Total Cost	Federal Cost	Local Sponsor	State
Flood Control	$37,740,000	$28,300,000	$ 7,550,000	$1,890,000
Recreation	4,660,000	2,100,000	2,330,000	230,000
Environmental Quality	1,400,000	630,000	700,000	70,000
TOTALS	$43,800,000	$31,030,000	$10,580,000	$2,190,000

TABLE E-2
MALINE CREEK
DETAILED COST SUMMARY FOR THE PRESIDENT'S
COST-SHARING POLICY

Flood Control

01	Lands and Damages	$ 9,840,000
02	Relocations	2,720,000
04	Dams	6,170,000
09	Channels and Canals	5,570,000
11	Levees and Floodwalls	8,850,000
30	Engineering and Design	2,840,000
31	Supervision and Administration	1,750,000
	Total Flood Control	$37,740,000

Recreation

01	Lands and Damages	$ 1,300,000
14	Recreation	2,800,000
30	Engineering and Design	350,000
31	Supervision and Administration	210,000
	Total Recreation	$ 4,660,000

Environmental Quality

06	Fish and Wildlife	$1,170,000
30	Engineering and Design	140,000
31	Supervision and Administration	90,000
	Total Environmental Quality	$ 1,400,000
	TOTAL PROJECT COST	$43,800,000

TABLE E-3
MALINE CREEK
COST SUMMARY FOR THE SELECTED PLAN
TRADITIONAL CONSTRUCTION COST APPORTIONMENT

FEDERAL COSTS		TOTAL ESTIMATED COST
01	Lands and Damages[1/]	$ 840,000
04	Dams	6,170,000
06	Fish and Wildlife	880,000
09	Channels and Canals	5,570,000
11	Levees and Floodwalls	8,850,000
14	Recreation	1,400,000
30	Engineering and Design	2,750,000
31	Supervision and Administration	1,680,000
	TOTAL FEDERAL COSTS	$28,140,000
NON-FEDERAL COSTS		
01	Lands and Damages[1/]	$10,300,000
02	Relocations	2,720,000
06	Fish and Wildlife	290,000
14	Recreation	1,400,000
30	Engineering and Design	580,000
31	Supervision and Administration	370,000
	TOTAL NON-FEDERAL COSTS	$15,660,000
	TOTAL PROJECT COSTS	$43,800,000

[1/] Lands and damages for nonstructural flood control features of the plan of improvements are cost shared 80 percent Federal and 20 percent non-Federal for the "Traditional Construction Cost Apportionment."

TABLE E-4
MALINE CREEK
DETAILED COST ESTIMATE FOR THE SELECTED PLAN
CONSTRUCTION COSTS - FEDERAL
TRADITIONAL CONSTRUCTION COST APPORTIONMENT

Cost Acct. No.	Item	Quantity	Unit	Unit Price	Total Estimated Cost
01	Lands and Damages				($ 840,000)
	Stream Corridor Land				
	Land for nonstructural	29	Ac.	2,500.00	72,500
	flood protection (80%)	13	Ac.	2,700.00	35,100
	SUBTOTAL				107,600
	Improvements				
	Nonstructural Flood protection (80%)	sum	job		180,000
	SUBTOTAL				180,000
	Damages				
	Nonstructural Flood protection (80%)	sum	job		29,520
	SUBTOTAL				29,520
	Subtotal Land, Improvements and Damages				$ 317,120
	Contingencies				79,280
	SUBTOTAL NONSTRUCTURAL FLOOD CONTROL STREAM CORRIDOR				$ 396,400
	Relocation Assistance	sum	job		25,520
	Acquisition Costs	sum	job		416,000
	TOTAL NONSTRUCTURAL FLOOD CONTROL STREAM CORRIDOR				$ 837,920
	ROUND TO AGREE WITH APPRAISAL DATED 30 MAY 1980				840,000
04	DAMS				($6,170,000)
	Detention Basins				
	M27				
	Diversion and Care of Flow	sum	job		$ 44,000

TABLE E-4 (Continued)
MALINE CREEK
DETAILED COST ESTIMATE FOR THE SELECTED PLAN
CONSTRUCTION COSTS - FEDERAL
TRADITIONAL CONSTRUCTION COST APPORTIONMENT

Cost Acct. No.	Item	Quantity	Unit	Unit Price	Total Estimated Cost
	Emergency Spillway				
	Excavation	15,240	C.Y.	2.40	36,576
	Concrete	240	C.Y.	180.00	43,200
	Reinforcing Steel	48,000	Lb.	0.60	28,800
	Sheet Piling PMA-22	2,880	S.F.	15.00	43,200
	Riprap 400 lb.	1,800	Ton	18.00	32,400
	Bedding Material	960	Ton	15.00	14,400
	Dam Embankment				
	Clearing & Grubbing	7	Ac.	1,500.00	10,500
	Stripping	2,700	C.Y.	1.20	3,240
	Embankment Fill	42,150	C.Y.	4.00	168,600
	Riprap	720	Ton	18.00	12,960
	Bedding Material	360	Ton	15.00	5,400
	Topsoil	2,500	C.Y.	4.00	10,000
	Sodding	480	S.Y.	3.00	1,440
	Seeding	8	Ac.	1,200.00	9,600
	Filter Gravel	1,500	Ton	12.00	18,000
	Sand	8,720	Ton	12.00	104,640
	Trench Excavation	1,400	C.Y.	2.40	3,360
	Culvert 4' dia.	238	L.F.	85.00	20,230
	Crushed Stone	240	Ton	12.00	2,880
	SUB-TOTAL				$ 613,426
	CONTINGENCIES				156,574
	TOTAL FOR M27				$ 770,000
	M22				
	Diversion and Care of Flow	sum	job		$ 44,000
	Emergency Spillway				
	Excavation	12,840	C.Y.	2.40	30,816
	Concrete	198	C.Y.	180.00	35,640
	Reinforcing Steel	28,800	Lb.	0.60	17,280
	Sheet Piling PMA-22	1,920	S.F.	15.00	28,800
	Riprap 400 lb.	1,200	Ton	18.00	21,600
	Bedding Material	600	Ton	15.00	9,000

TABLE E-4 (Continued)
MALINE CREEK
DETAILED COST ESTIMATE FOR THE SELECTED PLAN
CONSTRUCTION COSTS - FEDERAL
TRADITIONAL CONSTRUCTION COST APPORTIONMENT

Cost Acct. No.	Item	Quantity	Unit	Unit Price	Total Estimated Cost
	Dam Embankment				
	Clearing & Grubbing	4.2	Ac.	1,500.00	[illegible]
	Stripping	2,000	C.Y.	1.20	[illegible]
	Embankment Fill	25,920	C.Y.	4.00	10[illegible]
	Riprap	600	Ton	18.00	1[illegible]
	Bedding Material	300	Ton	15.00	[illegible]
	Topsoil	1,800	C.Y.	4.00	[illegible]
	Sodding	420	S.Y.	3.00	[illegible]
	Seeding	8.4	Ac.	1,200.00	1[illegible]
	Filter Gravel	1,200	Ton	12.00	1[illegible]
	Sand	5,080	Ton	12.00	6[illegible]
	Trench Excavation	2,250	C.Y.	2.40	[illegible]
	Culvert 4'dia.	194	L.F.	85.00	1[illegible]
	Crushed Stone	240	Ton	12.00	[illegible]
	SUB-TOTAL				$ 43[illegible]
	CONTINGENCIES				10[illegible]
	TOTAL FOR M22				$ 54[illegible]
	MH1				
	Diversion and Care of Flow	sum	job		$ 4[illegible]
	Emergency Spillway				
	Excavation	2,160	C.Y.	2.40	[illegible]
	Concrete	30	C.Y.	180.00	[illegible]
	Reinforcing Steel	4,800	Lb.	0.60	[illegible]
	Sheet Piling PMA-22	1,440	S.F.	15.00	21[illegible]
	Riprap 400 lb.	90	Ton	18.00	1[illegible]
	Bedding Material	54	Ton	15.00	
	Capstone 2,000 lb.	60	Ton	24.00	1[illegible]
	Backfill	360	C.Y.	4.00	1[illegible]
	Dam Embankment				
	Clearing & Grubbing	10	Ac.	1,500.00	15[illegible]
	Stripping	4,100	C.Y.	1.20	4[illegible]
	Embankment Fill	53,040	C.Y.	4.00	212[illegible]
	Riprap	720	Ton	18.00	12[illegible]
	Bedding Material	360	Ton	15.00	5[illegible]

TABLE E-4 (Continued)
MALINE CREEK
DETAILED COST ESTIMATE FOR THE SELECTED PLAN
CONSTRUCTION COSTS - FEDERAL
TRADITIONAL CONSTRUCTION COST APPORTIONMENT

Cost Acct. No.	Item	Quantity	Unit	Unit Price	Total Estimated Cost
	Topsoil	3,900	C.Y.	4.00	15,600
	Sodding	960	S.Y.	3.00	2,880
	Seeding	19	Ac.	1,200.00	22,800
	Filter Gravel	1,680	Ton	12.00	20,160
	Sand	8,500	Ton	12.00	102,000
	Trench Excavation	3,170	C.Y.	2.40	7,608
	Culvert 3' dia.	288	L.F.	65.00	18,720
	Crushed Stone	240	Ton	12.00	2,880
	SUB-TOTAL				$ 527,462
	CONTINGENCIES				132,530
	TOTAL FOR MH1				$ 660,000
	MF1				
	Diversion and Care of Flow	sum	job		$ 44,000
	Emergency Spillway				
	Excavation	32,160	C.Y.	2.40	77,184
	Concrete	378	C.Y.	180.00	68,040
	Reinforcing Steel	57,600	Lb.	0.60	34,560
	Sheet Piling PMA-22	4,800	S.F.	15.00	72,000
	Riprap 400 lb.	2,640	Ton	18.00	47,520
	Bedding Material	1,320	Ton	15.00	19,800
	Dam Embankment				
	Clearing & Grubbing	5	Ac.	1,500.00	7,500
	Stripping	2,400	C.Y.	1.20	2,880
	Embankment Fill	23,700	C.Y.	4.00	94,800
	Riprap	600	Ton	18.00	10,800
	Bedding Material	300	Ton	15.00	4,500
	Topsoil	2,280	C.Y.	4.00	9,120
	Sodding	540	S.Y.	3.00	1,620
	Seeding	10	Ac.	1,200.00	12,000
	Filter Gravel	1,320	Ton	12.00	15,840
	Sand	5,560	Ton	12.00	67,920
	Trench Excavation	2,305	C.Y.	2.40	5,532

TABLE E-4 (Continued)
MALINE CREEK
DETAILED COST ESTIMATE FOR THE SELECTED PLAN
CONSTRUCTION COSTS - FEDERAL
TRADITIONAL CONSTRUCTION COST APPORTIONMENT

Cost Acct. No.	Item	Quantity	Unit	Unit Price	Total Estimated Cost
	Culvert 2' dia.	202	L.F.	60.00	12,120
	Crushed Stone	240	Ton	12.00	2,880
	SUB-TOTAL				$ 610,616
	CONTINGENCIES				149,384
	TOTAL FOR MF1				$ 760,000
	MF2				
	Diversion and Care of Flow	sum	job		$ 44,000
	Emergency Spillway				
	Excavation	33,000	C.Y.	2.40	79,200
	Concrete	720	C.Y.	180.00	129,600
	Reinforcing Steel	108,000	Lb.	0.60	64,800
	Sheet Piling PMA-22	9,600	S.F.	15.00	144,000
	Riprap 400 lb.	1,560	Ton	18.00	28,080
	Bedding Material	780	Ton	15.00	11,700
	Dam Embankment				
	Clearing & Grubbing	1.6	Ac.	1,500.00	2,400
	Stripping	2,280	C.Y.	1.20	2,736
	Embankment Fill	21,360	C.Y.	4.00	85,540
	Riprap	432	Ton	18.00	7,776
	Bedding Material	216	Ton	15.00	3,240
	Topsoil	2,180	C.Y.	4.00	8,720
	Sodding	600	S.Y.	3.00	1,800
	Seeding	3.1	Ac.	1,200.00	3,720
	Filter Gravel	960	Ton	12.00	11,520
	Sand	4,950	Ton	12.00	59,400
	Trench Excavation	1,900	C.Y.	2.40	4,560
	Culvert 2' dia.	216	L.F.	60.00	12,960
	Crushed Stone	140	Ton	12.00	1,680
	SUB-TOTAL				$ 707,332
	CONTINGENCIES				172,668
	TOTAL FOR MF2				$ 880,000

TABLE E-4 (Continued)
MALINE CREEK
DETAILED COST ESTIMATE FOR THE SELECTED PLAN
CONSTRUCTION COSTS - FEDERAL
TRADITIONAL CONSTRUCTION COST APPORTIONMENT

Cost Acct. No.	Item	Quantity	Unit	Unit Price	Total Estimated Cost
	MD1				
	Diversion and Care of Flow	sum	job		$ 44,000
	Emergency Spillway				
	Excavation	13,200	C.Y.	2.40	$ 31,680
	Concrete	1,056	C.Y.	180.00	190,080
	Reinforcing Steel	156,000	Lb.	0.60	93,600
	Sheet Piling PMA-22	19,200	S.F.	15.00	288,000
	Riprap 400 lb.	840	Ton	18.00	15,120
	Bedding Material	420	Ton	15.00	6,300
	Dam Embankment				
	Clearing & Grubbing	1.2	Ac.	1,500.00	1,800
	Stripping	2,040	C.Y.	1.20	2,448
	Embankment Fill	12,600	C.Y.	4.00	50,400
	Riprap	600	Ton	18.00	10,800
	Bedding Material	300	Ton	15.00	4,500
	Topsoil	1,680	C.Y.	4.00	6,720
	Sodding	120	S.Y.	3.00	360
	Seeding	2.4	Ac.	1,200.00	2,880
	Filter Gravel	1,200	Ton	12.00	14,400
	Sand	1,740	Ton	12.00	20,880
	Trench Excavation	2,840	C.Y.	2.40	6,816
	Culvert 5' dia.	120	L.F.	120.00	14,400
	Crushed Stone	200	Ton	12.00	2,400
	SUB-TOTAL				$ 807,504
	CONTINGENCIES				202,416
	TOTAL FOR MD1				$ 1,010,000
	MD2-2				
	Diversion and Care of Flow	sum	job		$ 44,000
	Emergency Spillway				
	Excavation	34,320	C.Y.	2.40	82,368
	Concrete	288	C.Y.	180.00	51,840

TABLE E-4 (Continued)
MALINE CREEK
DETAILED COST ESTIMATE FOR THE SELECTED PLAN
CONSTRUCTION COSTS - FEDERAL
TRADITIONAL CONSTRUCTION COST APPORTIONMENT

Cost Acct. No.	Item	Quantity	Unit	Unit Price	Total Estimated Cost
	Reinforcing Steel	43,200	Lb.	0.60	25,920
	Sheet Piling PMA-22	3,360	S.F.	15.00	50,400
	Riprap 400 lb.	1,680	Ton	18.00	30,240
	Bedding Material	840	Ton	15.00	12,600
	Dam Embankment				
	Clearing & Grubbing	2.4	Ac.	1,500.00	3,600
	Stripping	1,790	C.Y.	1.20	2,148
	Embankment Fill	22,960	C.Y.	4.00	91,840
	Riprap	480	Ton	18.00	8,640
	Bedding Material	240	Ton	15.00	3,600
	Topsoil	1,620	C.Y.	4.00	6,480
	Sodding	960	S.Y.	3.00	2,880
	Seeding	4.8	Ac.	1,200.00	5,760
	Filter Gravel	960	Ton	12.00	11,520
	Sand	4,560	Ton	12.00	54,720
	Trench Excavation	1,900	C.Y.	2.40	4,560
	Culvert 4' dia.	202	L.F.	85.00	17,170
	Crushed Stone	170	Ton	12.00	2,040
	SUB-TOTAL				$ 512,326
	CONTINGENCIES				127,674
	TOTAL FOR MD2-2				$ 640,000
	MD1-1				
	Diversion and Care of Flow	sum	job		$ 44,000
	Emergency Spillway				
	Excavation	21,240	C.Y.	2.40	50,976
	Concrete	540	C.Y.	180.00	97,200
	Reinforcing Steel	79,200	Lb.	0.60	47,520
	Sheet Piling PMA-22	7,680	S.F.	15.00	115,200
	Riprap 400 lb.	1,800	Ton	18.00	32,400
	Bedding Material	900	Ton	15.00	13,500

TABLE E-4 (Continued)
MALINE CREEK
DETAILED COST ESTIMATE FOR THE SELECTED PLAN
CONSTRUCTION COSTS - FEDERAL
TRADITIONAL CONSTRUCTION COST APPORTIONMENT

Cost Acct. No.	Item	Quantity	Unit	Unit Price	Total Estimated Cost
	Dam Embankment				
	Clearing & Grubbing	6	Ac.	1,500.00	9,000
	Stripping	2,760	C.Y.	1.20	3,312
	Embankment Fill	35,520	C.Y.	4.00	142,080
	Riprap	600	Ton	18.00	10,800
	Bedding Material	300	Ton	15.00	4,500
	Topsoil	2,640	C.Y.	4.00	10,560
	Sodding	2,400	S.Y.	3.00	7,200
	Seeding	12	Ac.	1,200.00	14,400
	Filter Gravel	1,440	Ton	12.00	17,280
	Sand	6,540	Ton	12.00	78,480
	Trench Excavation	2,685	C.Y.	2.40	6,444
	Culvert 4' dia.	212	L.F.	85.00	18,020
	Crushed Stone	200	Ton	12.00	2,400
	SUB-TOTAL				$ 725,272
	CONTINGENCIES				184,728
	TOTAL FOR MD1-1				$ 910,000
	TOTAL FOR DETENTION BASINS				$ 6,170,000
	TOTAL FOR DAMS				$ 6,170,000
06	FISH AND WILDLIFE (75% Federal, 25% Non-Federal)				($ 880,000)
	Aquatic Habitat Structure				
	Excavation	3,400	C.Y.	5.00	$ 17,000
	Gabions	1,275	C.Y.	110.00	140,250
	Filter Cloth	2,890	S.Y	5.00	14,450
	SUB-TOTAL				$ 171,700
	CONTINGENCIES				38,300
	TOTAL AQUATIC HABITAT STRUCTURE				$ 210,000
	Fish Ponds				
	Downstream of Detention Basin M27	sum	job		$ 129,000

TABLE E-4 (Continued)
MALINE CREEK
DETAILED COST ESTIMATE FOR THE SELECTED PLAN
CONSTRUCTION COSTS - FEDERAL
TRADITIONAL CONSTRUCTION COST APPORTIONMENT

Cost Acct. No.	Item	Quantity	Unit	Unit Price	Total Estimated Cost
	SUBTOTAL				$ 129,000
	CONTINGENCIES				31,000
	TOTAL				$ 160,000
	Downstream of Detention Basin M22	sum	job		$ 154,000
	SUBTOTAL				$ 154,000
	CONTINGENCIES				36,000
	TOTAL				$ 190,000
	Downstream of Detention Basin MH1	sum	job		$ 117,000
	SUBTOTAL				$ 117,000
	CONTINGENCIES				33,000
	TOTAL				$ 150,000
	Downstream of Detention Basin MD2-2	sum	job		$ 135,000
	SUBTOTAL				$ 135,000
	CONTINGENCIES				35,000
	TOTAL				$ 170,000
	Downstream of Detention Basin MD1-1	sum	job		$ 232,000
	SUBTOTAL				$ 232,000
	CONTINGENCIES				58,000
	TOTAL				$ 290,000
	TOTAL FOR FISH PONDS				$ 960,000
	TOTAL FOR FISH AND WILDLIFE				$ 1,170,000
	75% Federal Cost				$ 880,000
	25% Non-Federal Cost				$ 290,000

TABLE E-4 (Continued)
MALINE CREEK
DETAILED COST ESTIMATE FOR THE SELECTED PLAN
CONSTRUCTION COSTS - FEDERAL
TRADITIONAL CONSTRUCTION COST APPORTIONMENT

Cost Acct. No.	Item	Quantity	Unit	Unit Price	Total Estimated Cost
09	CHANNELS AND CANALS				($ 5,570,000)
	Channels				
	Excavation	616,000	C.Y.	5.00	$ 3,080,000
	Clearing	72	Ac.	1,200.00	86,400
	Seeding	49	Ac.	1,200.00	58,800
	Care of Flow	sum	job		210,000
	Bedding Material	5,600	Ton	15.00	84,000
	Litter & Debris Removal	sum	job		40,000
	Riprap	11,200	Ton	18.00	201,600
	SUB-TOTAL				$ 3,760,800
	CONTINGENCIES				939,200
	TOTAL CHANNELS				$ 4,700,000
	Grade Control Structures				
	Excavation	550	C.Y.	5.00	$ 2,750
	Gabions	660	C.Y	110.00	72,600
	Filter Cloth	1,760	S.Y.	5.00	8,800
	SUB-TOTAL				$ 84,150
	CONTINGENCIES				25,850
	TOTAL GRADE CONTROL STRUCTURES				$ 110,000
	Selective Clearing				
	Clearing	77	Ac.	300.00	$ 23,100
	SUB-TOTAL				$ 23,100
	CONTINGENCIES				6,900
	TOTAL FOR SELECTIVE CLEARING				$ 30,000
	Streambank Stabilization				
	Excavation	16,200	C.Y.	5.00	$ 81,000
	Filter Cloth	37,700	S.Y	4.50	169,650
	Riprap	18,700	Ton	18.00	336,600

TABLE E-4 (Continued)
MALINE CREEK
DETAILED COST ESTIMATE FOR THE SELECTED PLAN
CONSTRUCTION COSTS - FEDERAL
TRADITIONAL CONSTRUCTION COST APPORTIONMENT

Cost Acct. No.	Item	Quantity	Unit	Unit Price	Total Estimated Cost
	SUB-TOTAL				$ 587,250
	CONTINGENCIES				142,750
	TOTAL STREAMBANK STABILIZATION				$ 730,000
	TOTAL FOR CHANNELS AND CANALS				$ 5,570,000
11	Levees and Floodwalls				($ 8,850,000)
	Low Level Earth Protectors				
	Clearing	7	Ac.	1,200.00	$ 8,400
	Excavation	2,100	C.Y.	3.00	6,300
	Stripping	17,500	C.Y	2.00	35,000
	Embankment Fill	35,350	C.Y	5.00	176,750
	Seeding	11	Ac.	1,000.00	11,000
	Fences and Landscaping	sum	job		175,000
	SUB-TOTAL				$ 412,450
	CONTINGENCIES				107,550
	TOTAL LOW LEVEL EARTH PROTECTORS				$ 520,000
	Low Level Concrete Protectors				
	Clearing	11	Ac.	1,200.00	$ 13,200
	Excavation	38,400	C.Y.	3.00	115,200
	Backfill	29,600	C.Y.	2.00	59,200
	Seeding	22	Ac.	1,000.00	22,000
	Concrete	10,660	C.Y.	200.00	2,132,000
	Riprap	2,200	Ton	18.00	39,600
	Bedding Material	1,100	Ton	15.00	16,500
	Waterstops	14,700	L.F.	10.00	147,000
	Fences and Landscaping	sum	job		$ 266,500
	SUB-TOTAL				$ 2,811,200
	CONTINGENCIES				708,800
	TOTAL LOW LEVEL CONCRETE PROTECTORS				$ 3,520,000

TABLE E-4 (Continued)
MALINE CREEK
DETAILED COST ESTIMATE FOR THE SELECTED PLAN
CONSTRUCTION COSTS - FEDERAL
TRADITIONAL CONSTRUCTION COST APPORTIONMENT

Cost Acct. No.	Item	Quantity	Unit	Unit Price	Total Estimated Cost
	Interior Drainage System				
	Catch Basins	212	EA	1,500.00	$ 318,000
	Excavation and Grading	10,600	C.Y.	5.00	53,000
	Seeding	38	Ac.	1,500.00	57,000
	Sodding	7,400	S.Y.	3.00	22,200
	Collector Pipe 12" dia.	6,800	L.F.	25.00	170,000
	Collector Pipe 16" dia.	11,400	L.F.	35.00	399,000
	Collector Pipe 24" dia.	18,800	L.F.	50.00	940,000
	Outfall Pipe 16" dia.	13,000	L.F.	35.00	455,000
	Outfall Pipe 24" dia.	10,000	L.F.	50.00	500,000
	Outfall Pipe 36" dia.	8,000	L.F.	75.00	600,000
	SUB-TOTAL				$ 3,514,200
	CONTINGENCIES				875,800
	TOTAL INTERIOR DRAINAGE SYSTEM				$ 4,390,000
	Sewer Modifications				
	10" dia. Sewer Outfall with Gate	1	EA.	2,700.00	$ 2,700
	12" dia. Sewer Outfall with Gate	6	EA.	2,900.00	17,400
	15" dia. Sewer Outfall with Gate	7	EA.	3,500.00	24,500
	18" dia. Sewer Outfall with Gate	5	EA.	4,000.00	20,000
	21" dia. Sewer Outfall with Gate	5	EA.	4,800.00	24,000
	24" dia. Sewer Outfall with Gate	4	EA.	5,200.00	20,800
	27" dia. Sewer Outfall with Gate	4	EA.	6,200.00	24,800
	30" dia. Sewer Outfall with Gate	5	EA.	6,700.00	33,500
	33" dia. Sewer Outfall with Gate	1	EA.	7,700.00	7,700
	36" dia. Sewer Outfall with Gate	4	EA.	8,200.00	32,800
	40" dia. Sewer Outfall with Gate	1	EA.	9,400.00	9,400

TABLE E-4 (Continued)
MALINE CREEK
DETAILED COST ESTIMATE FOR THE SELECTED PLAN
CONSTRUCTION COSTS - FEDERAL
TRADITIONAL CONSTRUCTION COST APPORTIONMENT

Cost Acct. No.	Item	Quantity	Unit	Unit Price	Total Estimated Cost
	42" dia. Sewer Outfall with Gate	2	EA.	10,200.00	20,400
	48" dia. Sewer Outfall with Gate	1	EA.	12,500.00	12,500
	54" dia. Sewer Outfall with Gate	1	EA.	14,400.00	14,400
	60" dia. Sewer Outfall with Gate	3	EA.	16,900.00	50,700
	78" dia. Sewer Outfall with Gate	1	EA.	23,800.00	23,800
	SUB-TOTAL				$ 339,400
	CONTINGENCIES				80,600
	TOTAL FOR SEWER MODIFICATIONS				$ 420,000
	TOTAL FOR LEVEES AND FLOODWALLS				$ 8,850,000
14	Recreation (1/2 federal, 1/2 non-federal)				($ 1,400,000)
	Stream Corridor				
	Seeding	6	Ac.	1,200.00	$ 7,200
	Planting	sum	job		205,000
	Trails	32,200	S.Y.	5.50	177,100
	Comfort Station	1	Ea.	30,500.00	30,500
	Pedestrian Bridges	8	Ea.	25,000.00	200,000
	SUB-TOTAL				$ 619,800
	CONTINGENCIES				150,200
	TOTAL STREAM CORRIDOR				$ 770,000
	Detention Basins				
	M27				
	Site Grading	sum	job		$ 18,300
	Seeding	5	Ac.	1,200.00	6,000

TABLE E-4 (Continued)
MALINE CREEK
DETAILED COST ESTIMATE FOR THE SELECTED PLAN
CONSTRUCTION COSTS - FEDERAL
TRADITIONAL CONSTRUCTION COST APPORTIONMENT

Cost Acct. No.	Item	Quantity	Unit	Unit Price	Total Estimated Cost
	Planting	sum	job		29,300
	Trails	6,100	S.Y.	5.50	33,550
	Asphaltic Concrete Pavement Structure	12,900	S.Y.	11.00	141,900
	Comfort Station	2	Ea.	30,500.00	61,000
	Picnic Units	40	Ea.	370.00	14,800
	Game Fields	4	Ac.	4,880.00	19,520
	Water Supply	sum	job		10,000
	Sewer	sum	job		10,000
	SUB-TOTAL				$ 344,370
	CONTINGENCIES				85,630
	TOTAL FOR M27				$ 430,000
	M22				
	Site Grading	sum	job		$ 18,300
	Seeding	5	Ac.	1,200.00	6,000
	Planting	sum	job		25,000
	Trails	7,040	S.Y.	5.50	38,720
	Asphaltic Concrete Pavement Structure	8,040	S.Y.	11.00	88,440
	Comfort Station	2	Ea.	30,500.00	61,000
	Picnic Units	15	Ea.	370.00	5,550
	Game Fields	3	Ac.	1,200.00	3,600
	Water Supply	sum	job		15,250
	Sewer	sum	job		15,250

TABLE E-4 (Continued)
MALINE CREEK
DETAILED COST ESTIMATE FOR THE SELECTED PLAN
CONSTRUCTION COSTS - FEDERAL
TRADITIONAL CONSTRUCTION COST APPORTIONMENT

Cost Acct. No.	Item	Quantity	Unit	Unit Price	Total Estimated Cost
	SUB-TOTAL				$ 277,110
	CONTINGENCIES				72,890
	TOTAL FOR M22				$ 350,000
	MH1				
	Site Grading	sum	job		$ 18,300
	Seeding	5	Ac.	1,200.00	6,000
	Planting	sum	job		25,600
	Trails	6,100	S.Y.	5.50	33,550
	Asphaltic Concrete Pavement Structure	8,400	S.Y.	11.00	92,400
	Comfort Station	2	Ea.	30,500.00	61,000
	Picnic Units	40	Ea.	370.00	14,800
	Game Fields	5	Ac.	1,200.00	6,000
	Water Supply	sum	job		12,200
	Sewer	sum	job		12,200
	SUB-TOTAL				$ 282,050
	CONTINGENCIES				67,950
	TOTAL FOR MH1				$ 350,000
	MF1				
	Site Grading	sum	job		$ 6,100
	Seeding	3	Ac.	1,200.00	3,600
	Planting	sum	job		21,960
	Trails	2,350	S.Y.	5.50	12,925
	Asphaltic Concrete Pavement Structure	2,100	S.Y.	11.00	23,100
	Comfort Station	1	Ea.	18,300.00	18,300
	Picnic Units	20	Ea.	370.00	7,400
	Water Supply	sum	job		6,100
	Sewer	sum	job		6,100

TABLE E-4 (Continued)
MALINE CREEK
DETAILED COST ESTIMATE FOR THE SELECTED PLAN
CONSTRUCTION COSTS - FEDERAL
TRADITIONAL CONSTRUCTION COST APPORTIONMENT

Cost Acct. No.	Item	Quantity	Unit	Unit Price	Total Estimated Cost
	SUB-TOTAL				$ 105,585
	CONTINGENCIES				24,415
	TOTAL FOR MF1				$ 130,000
	MF2				
	Site Grading	sum	job		$ 9,760
	Seeding	2	Ac.	1,200.00	2,400
	Planting	sum	job		14,640
	Trails	1,400	S.Y.	5.50	7,700
	Asphaltic Concrete Pavement Structure	1,700	S.Y.	11.00	18,700
	Comfort Station	1	Ea.	30,500.00	30,500
	Picnic Units	20	Ea.	370.00	7,400
	Game Fields	2	Ac.	1,200.00	2,400
	Water Supply	sum	job		6,100
	Sewer	sum	job		6,100
	SUB-TOTAL				$ 105,700
	CONTINGENCIES				24,300
	TOTAL FOR MF2				$ 130,000
	MD1				
	Site Grading	sum	job		$ 12,200
	Seeding	4	Ac.	1,200.00	4,800
	Planting	sum	job		25,600
	Trails	1,170	S.Y.	5.50	6,435
	Asphaltic Concrete Pavement Structure	3,300	S.Y.	11.00	36,300
	Comfort Station	1	Ea.	30,500.00	30,500
	Picnic Units	20	Ea.	370.00	7,400
	Game Fields	2	Ac.	1,200.00	2,400

TABLE E-4 (Continued)
MALINE CREEK
DETAILED COST ESTIMATE FOR THE SELECTED PLAN
CONSTRUCTION COSTS - FEDERAL
TRADITIONAL CONSTRUCTION COST APPORTIONMENT

Cost Acct. No.	Item	Quantity	Unit	Unit Price	Total Estimated Cost
	Water Supply	sum	job		6
	Sewer	sum	job		6
	SUB-TOTAL				$ 137
	CONTINGENCIES				32
	TOTAL FOR MD1				$ 170
	MD2-2				
	Site Grading	sum	job		$ 12
	Seeding	5	Ac.	1,200.00	6
	Planting	sum	job		22
	Trails	4,700	S.Y.	5.50	25
	Asphaltic Concrete Pavement Structure	1,330	S.Y.	11.00	14
	Comfort Station	1	Ea.	30,500.00	30
	Picnic Units	40	Ea.	370.00	14
	Group Camping	2	Ac.	8,500.00	17
	Water Supply	sum	job		6
	Sewer	sum	job		6
	SUB-TOTAL				$ 155
	CONTINGENCIES				34
	TOTAL FOR MD2-2				$ 190
	MD1-1				
	Site Grading	sum	job		$ 18
	Seeding	6	Ac.	1,200.00	7
	Planting	sum	job		25
	Trails	4,700	S.Y.	5.50	25
	Asphaltic Concrete Pavement Structure	7,200	S.Y.	11.00	79

TABLE E-4 (Continued)
MALINE CREEK
DETAILED COST ESTIMATE FOR THE SELECTED PLAN
CONSTRUCTION COSTS - FEDERAL
TRADITIONAL CONSTRUCTION COST APPORTIONMENT

Cost Acct. No.	Item	Quantity	Unit	Unit Price	Total Estimated Cost
	Comfort Station	1	Ea.	30,500.00	30,500
	Picnic Units	40	Ea.	370.00	14,800
	Game Fields	3	Ac.	1,200.00	3,600
	Water Supply	sum	job		9,100
	Sewer	sum	job		9,100
	SUB-TOTAL				$ 223,250
	CONTINGENCIES				56,750
	TOTAL FOR MD1-1				$ 280,000
	TOTAL FOR DETENTION BASINS				$ 2,030,000
	TOTAL FOR RECREATION FACILITIES				$ 2,800,000
	1/2 FEDERAL COST				$ 1,400,000
	1/2 NON-FEDERAL COST				$ 1,400,000
30	ENGINEERING AND DESIGN				$ 2,750,000
31	SUPERVISON AND ADMINISTRATION				$ 1,680,000
	TOTAL FEDERAL COSTS				$ 28,140,000

TABLE E-5
MALINE CREEK
DETAILED COST ESTIMATE FOR THE SELECTED PLAN
CONSTRUCTION COSTS - NON-FEDERAL
TRADITIONAL CONSTRUCTION COST APPORTIONMENT

Cost Acct. No.	Item	Quantity	Unit	Unit Price	Total Estimated Cost
01	LANDS AND DAMAGES				($10,300,000)
	Land For Stuctural Flood Protection	340.45	Ac.	2,500.00	851,125
		16	Ac.	2,100.00	33,600
		36	Ac.	2,000.00	72,000
		18	Ac.	2,700.00	48,600
		120	F/F	750.00	90,000
		125	F/F	640.00	80,000
	Land For Nonstructural Flood Protection (20% of Total)	7	Ac.	2,500.00	17,500
		3	Ac.	2,700.00	8,100
	Land For EQ/Recreation	5	Ac.	2,000.00	10,000
		4	Ac.	2,700.00	10,800
		2	Ac.	2,500.00	5,000
	SUBTOTAL				$ 1,226,725
	Improvements For Structural Flood Protection				
	Private Ball Park and Improvements	sum	job		$ 190,000
	Jennings Park and Commercial Building	sum	job		368,300
	Ferguson Municipal Park Improvements and Commercial Building	sum	job		487,500
	Commercial Buildings Residences and Garages	sum	job		400,000
	6 Homes and 2 Garages	sum	job		109,000
	2 Buildings	sum	job		20,000
	Telephone Service Garage, Farm Buildings	sum	job		200,000

TABLE E-5 (Continued)
MALINE CREEK
DETAILED COST ESTIMATE FOR THE SELECTED PLAN
CONSTRUCTION COSTS - NON-FEDERAL
TRADITIONAL CONSTRUCTION COST APPORTIONMENT

Cost Acct. No.	Item	Quantity	Unit	Unit Price	Total Estimated Cost
	Parking Area	sum	job		$ 5,000
	Homes	26	EA.	40,000.00	1,040,000
	22 Homes and Misc. Buildings	sum	job		250,000
	Improvements For Nonstructural Flood Protection (20% of Total	sum	job		45,000
	SUB-TOTAL				$ 3,114,800
	Damages	sum	job		$ 433,392
	SUB-TOTAL				$ 433,392
	SUB-TOTAL LAND, IMPROVEMENTS AND DAMAGES				$ 4,774,917
	CONTINGENCIES				1,193,729
	SUB-TOTAL STREAM CORRIDOR				$ 5,968,646
	Relocation Assistance	sum	job		$ 680,380
	Acquisition Costs	sum	job		1,966,000
	TOTAL STREAM CORRIDOR				$ 8,615,026
	ROUND TO AGREE WITH APPRAISAL DATED 30 MAY 1980				$ 8,614,000
	Detention Basins				
	M27				
	Land for Flood Protection	20	Ac.	2,500.00	$ 50,000
	Land for EQ/Recreation	44	Ac.	2,500.00	110,000
	SUB-TOTAL				$ 160,000
	Damages	sum	job		16,000
	SUB-TOTAL				$ 16,000
	SUB-TOTAL LAND, IMPROVEMENTS AND DAMAGES				$ 176,000
	CONTINGENCIES				44,000

TABLE E-5 (Continued)
MALINE CREEK
DETAILED COST ESTIMATE FOR THE SELECTED PLAN
CONSTRUCTION COSTS - NON-FEDERAL
TRADITIONAL CONSTRUCTION COST APPORTIONMENT

Cost Acct. No.	Item	Quantity	Unit	Unit Price	Total Estimated Cost
	SUB-TOTAL M27				$ 220,000
	Acquisition Costs				40,000
	TOTAL FOR M27				$ 260,000
	M22				
	Land for Flood Protection	5	Ac.	2,500.00	$ 12,500
	Land for EQ/Recreation	56	Ac.	2,500.00	140,000
	SUB-TOTAL				$ 152,500
	Damages	sum	job		$ 15,250
	SUB-TOTAL				$ 15,250
	SUB-TOTAL LAND, IMPROVEMENTS AND DAMAGES				$ 167,750
	CONTINGENCIES				41,937
	SUB-TOTAL M22				$ 209,687
	Acquisition Costs				2,000
	TOTAL FOR M22				$ 211,687
	ROUND TO AGREE WITH APPRAISAL DATED 30 MAY 1980				$ 212,000
	MF1				
	Land for Flood Protection	20	Ac.	2,500.00	$ 50,000
	Land for EQ/Recreation	15	Ac.	2,500.00	37,500
	SUB-TOTAL				$ 87,500
	Damages	sum	job		8,750
	SUB-TOTAL				$ 8,750
	SUB-TOTAL LAND, IMPROVEMENTS AND DAMAGES				$ 96,250
	CONTINGENCIES				24,062

TABLE E-5 (Continued)
MALINE CREEK
DETAILED COST ESTIMATE FOR THE SELECTED PLAN
CONSTRUCTION COSTS - NON-FEDERAL
TRADITIONAL CONSTRUCTION COST APPORTIONMENT

Cost Acct. No.	Item	Quantity	Unit	Unit Price	Total Estimated Cost
	SUB-TOTAL MF1				$ 120,312
	Acquisitions Costs				2,000
	TOTAL FOR MF1				$ 122,312
	ROUND TO AGREE WITH APPRAISAL DATED 30 MAY 1980				$ 122,000
	MF2				
	Land for Flood Protection	6	Ac.	2,500.00	$ 15,000
	SUB-TOTAL				$ 15,000
	Damages	sum	job		$ 1,500
	SUB-TOTAL				$ 1,500
	SUB-TOTAL LAND, IMPROVEMENTS AND DAMAGES				$ 16,500
	CONTINGENCIES				4,125
	SUB-TOTAL MF2				$ 20,625
	Acquisition Costs				$ 10,000
	TOTAL FOR MF2				$ 30,625
	ROUND TO AGREE WITH APPRAISAL DATED 30 MAY 1980				$ 31,000
	MD1				
	Land for Flood Protection	10	Ac.	2,500.00	$ 25,000
	Land for EQ/Recreation	10	Ac.	2,500.00	25,000
	SUB-TOTAL				$ 50,000
	Damages	sum	job		$ 5,000
	SUB-TOTAL				$ 5,000
	SUB-TOTAL LAND, IMPROVEMENTS AND DAMAGES				$ 55,000
	CONTINGENCIES				13,750

TABLE E-5 (Continued)
MALINE CREEK
DETAILED COST ESTIMATE FOR THE SELECTED PLAN
CONSTRUCTION COSTS - NON-FEDERAL
TRADITIONAL CONSTRUCTION COST APPORTIONMENT

Cost Acct. No.	Item	Quantity	Unit	Unit Price	Total Estimated Cost
	SUB-TOTAL MD1				$ 68,750
	Acquisition Costs				70,000
	TOTAL FOR MD1				$ 138,750
	ROUND TO AGREE WITH APPRAISAL DATED 30 MAY 1980				$ 139,000
	MD2-2				
	Land for Flood Protection	11	Ac.	2,500.00	$ 27,500
	Land for EQ/Recreation	30	Ac.	2,500.00	75,000
	SUB-TOTAL				$ 102,500
	Damages	sum	job		$ 10,250
	SUB-TOTAL				$ 10,250
	SUB-TOTAL LAND, IMPROVEMENTS AND DAMAGES				$ 112,750
	CONTINGENCIES				28,000
	SUB-TOTAL MD2-2				$ 140,750
	Acquisition Costs				10,000
	TOTAL FOR MD2-2				$ 150,750
	ROUND TO AGREE WITH APPRAISAL DATED 30 MAY 1980				$ 151,000
	MD1-1				
	Land for Flood Protection	16	Ac.	2,500.00	$ 40,000
	Land for EQ/Recreation	57	Ac.	2,500.00	142,500
	SUB-TOTAL				$ 182,500
	Improvements	sum	job		$ 180,000
	SUB-TOTAL				$ 180,000
	Damages	sum	job		$ 36,250

TABLE E-5 (Continued)
MALINE CREEK
DETAILED COST ESTIMATE FOR THE SELECTED PLAN
CONSTRUCTION COSTS - NON-FEDERAL
TRADITIONAL CONSTRUCTION COST APPORTIONMENT

Cost Acct. No.	Item	Quantity	Unit	Unit Price	Total Estimated Cost
	SUB-TOTAL				$ 36,250
	SUB-TOTAL LAND, IMPROVEMENTS AND DAMAGES				$ 398,750
	CONTINGENCIES				99,687
	SUB-TOTAL MD1-1				$ 498,437
	Acquisition Costs				20,000
	TOTAL FOR MD1-1				$ 518,437
	ROUND TO AGREE WITH APPRAISAL DATED 30 MAY 1980				$ 518,000
	MB2				
	Land for EQ/Recreation	14	Ac.	2,500.00	$ 35,000
	SUB-TOTAL				$ 35,000
	Damages	sum	job		$ 3,500
	SUB-TOTAL				$ 3,500
	SUB-TOTAL LAND, IMPROVEMENTS AND DAMAGES				$ 38,500
	CONTINGENCIES				9,625
	SUB-TOTAL MB2				$ 48,125
	Acquisition Costs				10,000
	TOTAL FOR MB2				$ 58,125
	ROUND TO AGREE WITH APPRAISAL DATED 30 MAY 1980				$ 58,000
	MH1				
	Land for Flood Protection	16	Ac.	2,000.00	$ 32,000
	Land for EQ/Recreation	54	Ac.	2,000.00	108,000
	SUB-TOTAL				$ 140,000
	Damages	sum	job		$ 14,000

TABLE E-5 (Continued)
MALINE CREEK
DETAILED COST ESTIMATE FOR THE SELECTED PLAN
CONSTRUCTION COSTS - NON-FEDERAL
TRADITIONAL CONSTRUCTION COST APPORTIONMENT

Cost Acct. No.	Item	Quantity	Unit	Unit Price	Total Estimated Cost
	SUB-TOTAL				$ 14,000
	SUB-TOTAL LAND, IMPROVEMENTS AND DAMAGES				$ 154,000
	CONTINGENCIES				38,500
	SUB-TOTAL MH1				$ 192,500
	Acquisition Costs				2,000
	TOTAL FOR MH1				$ 194,500
	ROUND TO AGREE WITH APPRAISAL DATED 30 MAY 1980				$ 195,000
	Total for Detention Basins				$ 1,686,000
	Total for Lands and Damages				$10,300,000
02	RELOCATIONS				($ 2,720,000)
	Bellefontaine Road Bridge Replacement				
	Embankment	750	C.Y.	5.00	$ 3,750
	Pavement Structure	1,300	S.Y.	10.00	13,000
	Remove Existing Bridge	sum	job		50,000
	New Bridge	12,950	S.F.	40.00	518,000
	SUB-TOTAL				$ 584,750
	CONTINGENCIES				145,250
	TOTAL FOR BELLEFONTAINE ROAD BRIDGE				$ 730,000
	New Halls Ferry Road Bridge Replacement				
	Embankment	750	C.Y.	5.00	$ 3,750
	Pavement Structure	1,300	S.Y.	10.00	13,000
	Remove Existing Bridge	sum	job		50,000
	New Bridge	13,300	S.F.	40.00	532,000
	SUB-TOTAL				$ 598,750
	CONTINGENCIES				151,250
	TOTAL FOR NEW HALLS FERRY ROAD BRIDGE				$ 750,000

TABLE E-5 (Continued)
MALINE CREEK
DETAILED COST ESTIMATE FOR THE SELECTED PLAN
CONSTRUCTION COSTS - NON-FEDERAL
TRADITIONAL CONSTRUCTION COST APPORTIONMENT

Cost Acct. No.	Item	Quantity	Unit	Unit Price	Total Estimated Cost
	Glen Owen Drive Bridge Replacement				
	Embankment	750	C.Y.	5.00	$ 3,750
	Pavement Structure	1,200	S.Y.	10.00	12,000
	Remove Existing Bridge	sum	job		10,000
	New Bridge	1,650	S.F.	40.00	66,000
	SUB-TOTAL				$ 91,750
	CONTINGENCIES				18,250
	TOTAL FOR GLEN OWEN BRIDGE				$ 110,000
	West Florissant Ave. Bridge Replacement				
	Embankment	750	C.Y.	5.00	$ 3,750
	Pavement Structure	1,300	S.Y.	10.00	13,000
	Remove Existing Bridge	sum	job		40,000
	New Bridge	9,240	S.F.	40.00	369,600
	SUB-TOTAL				$ 426,350
	CONTINGENCIES				103,650
	TOTAL FOR WEST FLORISSANT AVE BRIDGE				$ 530,000
	Bermuda Ave Bridge Replacement				
	Embankment	4,000	C.Y.	5.00	$ 20,000
	Pavement Structure	2,000	S.Y.	10.00	20,000
	Remove Existing Bridge	sum	job		25,000
	New Bridge	6,160	S.F.	40.00	246,400
	SUB-TOTAL				$ 311,400
	CONTINGENCIES				78,600
	TOTAL FOR BERMUDA AVE BRIDGE				$ 390,000
	Railroad Culvert on MA				
	Excavation	1,000	C.Y	3.00	$ 3,000
	Backfill	1,000	C.Y	2.00	2,000
	Concrete	130	C.Y.	250.00	32,500
	Riprap	500	Ton	20.00	10,000
	Bedding Material	300	Ton	15.00	$ 4,500
	Care of Flow	sum	job		40,000
	Remove Existing Culvert	sum	job		20,000

TABLE E-5 (Continued)
MALINE CREEK
DETAILED COST ESTIMATE FOR THE SELECTED PLAN
CONSTRUCTION COSTS - NON-FEDERAL
TRADITIONAL CONSTRUCTION COST APPORTIONMENT

Cost Acct. No.	Item	Quantity	Unit	Unit Price	Total Estimated Cost
	SUB-TOTAL				$ 112,000
	CONTINGENCIES				28,000
	TOTAL FOR RAILROAD CULVERT				$ 140,000
	Aqueduct Bridge Demolition				
	Aqueduct Bridge Demolition	sum	job		$ 55,000
	SUB-TOTAL				$ 55,000
	CONTINGENCIES				15,000
	TOTAL FOR AQUEDUCT BRIDGE DEMOLITION				$ 70,000
	TOTAL FOR RELOCATIONS				$ 2,720,000
06	FISH AND WILDLIFE (See Previous Federal Fish and Wildlife Cost)				($ 290,000)
14	RECREATION (1/2 Federal, 1/2 non-Federal)				($ 1,400,000)
	See previous Federal Recreation Facilities cost.				
30	ENGINEERING AND DESIGN				$ 580,000
31	SUPERVISION AND ADMINISTRATION				$ 370,000
	TOTAL NON-FEDERAL COSTS				$ 15,660,000
	TOTAL PROJECT COSTS				$ 43,800,000

Rights-of-Way

13. Approximately 474 acres of permanent rights-of-way would be required for the stream corridor and approxmately 384 acres of permanent rights-of-way would be required for the detention basin sites, approximately 11 and 280 acres, respectively, are specifically for recreation. In addition, approximately 25 acres are required for temporary construction easements.

Operation and Maintenance Costs

14. Maintenance would include adequate measures to insure that the project objectives are maintained for the duration of the project life. Project components and associated assumed annual maintenance costs are shown in TABLE E-6. The annual maintenance costs include but are not limited to the following items of work: grass mowing, trash and debris removal, crushed stone repair, embankment inspection and repair, seeding and sodding, riprap repair, concrete repair, water supply, sewer fee, trash pickup, miscellaneous supplies, building and structure repair and maintenance, trail repair and pavement repair. The project would be transferred to the local sponsor for operation and maintenance immediately after completion. Subsequent to completion, an operation and maintenance manual would be prepared by the St. Louis District and furnished to the local sponsor.

TABLE E-6
MALINE CREEK
OPERATION AND MAINTENANCE COSTS
(ENTIRELY NON-FEDERAL COST)

ITEM	COST	PROJECT PURPOSE
Detention Sites (exluding recreation)	$ 58,900	Flood Control
Channel Improvements	74,700	Flood Control
Grade Control Structures	11,000	Flood Control
Stream Bank Stabilization	17,600	Flood Control
Selective Clearing	3,700	Flood Control
Levees and Floodwalls	64,000	Flood Control
Interior Drainage System	45,000	Flood Control
Sewer Modifications	4,200	Flood Control
Bridges	26,500	Flood Control
(Subtotal Flood Control)	($ 305,600)	
Fish Ponds	24,800	Environmental Quality
Aquatic Habitat Structures	17,000	Environmental Quality
(Subtotal Environmental Quality)	($ 41,800)	
Recreation	102,600	Recreation
(Subtotal Recreation)	($ 102,600)	
TOTAL O&M COSTS	$ 450,000	

MALINE CREEK, MISSOURI

SURVEY REPORT FOR FLOOD CONTROL
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APPENDIX F

RECREATION AND FISH AND WILDLIFE RESOURCES

APPENDIX F

RECREATION AND FISH AND WILDLIFE RESOURCES

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APPENDIX F

RECREATION AND FISH AND WILDLIFE RESOURCES

1. The purpose of this appendix is to present a concise report on the recreation and natural resources analysis conducted for this study. Information on the existing outdoor recreation and natural resources needs and opportunities served as the basis for projecting the future conditions. The future conditions time frame adopted for this study is 1990 to 2090 which is the basic analysis period for this entire study. A detailed discussion of the outdoor recreation and fish and wildlife inventories and projections is presented in APPENDIX A. The plan formulation process as it involves outdoor recreation and fish and wildlife concerns is presented in APPENDIX B.

OUTDOOR RECREATION

2. APPENDIX A contains a detailed analysis of the outdoor recreation problems, needs and opportunities within the Maline Creek basin. These concerns are summarized below.

Existing Outdoor Recreation

3. Existing outdoor recreation acreage (1970) is 737 acres. The existing unmet demand is 515 acres.

Future Recreation

4. By the year 2020 when the watershed is expected to be fully developed, the projected unmet demand is 943 acres. The Maline Creek basin is highly urbanized and has only 2 percent of the land remaining in agriculture or undeveloped land. Therefore, an

increase in recreation parklands is difficult to foresee or project. St. Louis County and a number of the cities have shown commendable inventiveness in acquiring lands as they become available. However, this is management of targets of opportunity and not a predictive tool for reducing the amount of recreation acres needed now or in the future.

5. The St. Louis County Parks and Recreation Department has an on-going study to evaluate linear parks on Gravois, Deer, Coldwater and Maline Creeks. Of the four creeks studied, two will be selected for implementation in the county, one creek corridor in the south and one creek corridor in the north. The study as it has progressed has been coordinated between agencies. When implementation is effected, the work will be mutually supportive. When, and if, implementation is started on Maline Creek, the recreation acres will be adjusted.

6. The estimated recreation activity needs (1980) are detailed in APPENDIX A. From the detailed list, a selection of activities compatible with the proposed dimension of this study which could be accommodated most efficiently and beneficially in scope and character were carried forward in the plans that finally developed into the Recommended Plan.

Recreation/Natural Resource Management Aspects of the Recommended Plan

7. Detention Sites. The acres proposed for flood control and recreation use for the Recommended Plan are listed in APPENDIX B. This table also details the costs for each type of purpose.

a. Recreation Activities. All detention areas would have nature walks and picnicking. Sites M27, M22 and MH1, in addition,

would have fish ponds, bicycling, and game fields. MF1, because of its ecological character, would be developed for nature walks and picnicking only. MD1 and MB2 would have additional bicycling and game fields. MD1-1 would have a fish pond, bicycling and game field facilities. MD2-2, because it is contiguous to the Little Creek Wildlife Area which is owned by the Ferguson/Florissant School District, would have group camping, a fish pond and the common nature walk and picnicking.

b. Protection of the Resource. Restrictions would be imposed on the local sponsors to retain and maintain the natural and restructured drainage through the life of the project. Restrictions would also be imposed to save existing natural growth and to encourage the preservation of comeback processes except in developed areas.

c. Future Development. As the Maline Creek study and coordination continues with the St. Louis County Department of Parks and Recreation, additional recreation activities will be considered for inclusion at particular sites. As previously mentioned in APPENDIX B, archery, fitness parcours and orienteering have been considered, but were dropped because benefits were difficult to establish at this time. Any future development will require investigation and approval from the St. Louis District Corps of Engineers. Such approval will be evaluated on the preservation and improvement of the resource.

8. Stream Corridor. The principal development of recreation activities would be accomplished within the 10-year flood plain except for trails and former detention site MB2. The lands in the MB2 area would provide a connection to Tanglewood Park (St. Louis County) and Wilderness Park (Bellefontaine Neighbors).

a. Recreation Activities. All segments of the stream corridor would provide opportunities for nature walk/hiking and bicycling. Reaches M1-M14 and MD1 would provide fishing opportunities in relation to the aquatic habitat structures that would be installed within these locations. Motorcycle and other off-road recreation vehicles would not be permitted on stream corridor trails.

b. Protection of the Resource. Same as for paragraph 7b. above.

c. Future Development. As previously mentioned, as this study continues through the phases to construction, a continuing coordination and evaluation process will be maintained with the St. Louis County Department of Parks and Recreation to evaluate additional recreation activities. Any future development after the completion of the project would be evaluated by the St. Louis District Corps of Engineers. Approval would be granted only after evaluating the preservation and improvement of the resource.

Extent and Location of Lands

9. Detention Sites. Most of the detention sites are at the outer fringes of the basin. All recreation lands at these sites were chosen to complement the designated flood control acres and to provide linkage and expansion of existing park lands. The lands were selected for their natural characteristics and evaluated for their existing growth. EQ and recreation features of the Recommended Plan are displayed on PLATE F-1.

10. The flood control land at the detention sites would be 104 acres. The added recreation acres would be 280. Therefore, the total lands at the detention sites would be 384 acres.

Costs to be Incurred.

11. A detailed cost breakdown is displayed in APPENDIX E

Cost-Sharing Requirements

12. Cost sharing requirements are discussed in APPENDIX E.

Administrative Responsibilities

13. The Main Report discusses administrative responsibilities.

FISH AND WILDLIFE RESOURCES

14. APPENDIX A contains a detailed analysis of the fish and wildlife resources related problems, needs, and opportunities within the Maline Creek basin. APPENDIX B outlines the formulation of measures to resolve these concerns. These concerns and their resolution are summarized in the following paragraphs.

Existing Environmental Conditions

15. Aquatic Communities. Lentic (flowing water) habitat within the Maline Creek watershed is limited to several small lakes or ponds, the largest of which is a 6.0-acre lake at January-Wabash Park in Ferguson. Interviews with owners or officials having jurisdiction over pond properties have revealed that at least some of these lakes or ponds have fish populations. Public fishing programs are provided at county and municipal facilities.

16. The lotic (flowing water) habitat within the Maline Creek watershed consists of 10.6 miles of Maline Creek main channel and 10 tributaries that vary in length from 1.4 to 4.2 miles (25.6 total

miles of tributary). Poor water quality and a lack of habitat diversity limit the variety and abundance of aquatic organisms that occur in this habitat. Aquatic organisms sampled from several sites within the watershed were generally pollution tolerant. With the exception of one site near the mouth of Maline Creek, the fish community collected from the stream sites consisted almost entirely of fathead minnows, a species that is tolerant of high temperatures, high turbidity, and low oxygen levels.

17. Terrestrial Communities. Most of the natural vegetation in the watershed has been replaced by urbanization. The largest amount of vegetative cover is mixed suburban, covering 77 percent of the watershed. This habitat type can vary in wildlife habitat value from the low-valued monoculture of a manicured lawn to a very diverse interspersion of trees, grass, and shrubs, which can be more productive of wildlife than natural forests in the watershed. The undeveloped, natural vegetation that remains in the watershed is mostly forest cover concentrated in large tracts with steep slopes in the northern portion of the watershed, and a band of forest vegetation along the stream borders. Most of these forest areas show signs of logging in the recent past, and are subjected to heavy human disturbance as well as high concentrations of dogs and cats which limit their value as wildlife habitat. Nevertheless, some of the tracts have a high diversity of faunal species. Bellefontaine County Park is known to be inhabited by cottontail rabbits, foxes, opossums, mice, skunks, raccoons, gray squirrels, and numerous bird species. Deer are occasionally sighted in the Little Creek Wildlife Area, located just north of I-270 and west of West Florissant Avenue.

18. Pestiferous Plants and Animals. The watershed is inhabited by a number of plants and animals that are a nuisance to human inhabitants. These include poison ivy, mosquitoes, ticks, and several warm-blooded animals (skunks, foxes, bats, rats, cats, and

dogs) that serve as vectors of rabies. However, consultation with local public health authorities has led to the conclusion that no significant public health problem exists in the watershed because of these pestiferous plants and animals.

19. Endangered or Threatened Species. Information gathered for this study has revealed that the Maline Creek watershed has no important habitat for species considered endangered, threatened or rare, either by the U.S. Fish and Wildlife Service or the state of Missouri. An endangered species assessment, that resulted in the conclusion that the Maline Creek project would result in no significant effect on federally-classified endangered species, may be found in APPENDIX I.

Projected Future Conditions If No Federal Action is Taken

20. Aquatic Communities. Some improvement in the quality of aquatic habitats is expected within the next decade, as an upgraded water quality effect resulting from Federal and state pollution control programs. However, aquatic species diversity is expected to remain quite low in the watershed because of a scarcity of stream habitat diversity and the shallow, silt-laden condition of most ponds or lakes in the watershed.

21. Terrestrial Communities. It has been projected that the Maline Creek watershed will undergo 100 percent development by the year 2020. This means that essentially all of the natural wildlife habitat currently existing on private lands will be cleared and converted to urban land uses. Some wildlife habitat in public parks may be maintained in their current condition.

Problems, Needs, and Opportunities Related to Fish and Wildlife Resources

22. Aquatic Communities. Two problems associated with the aquatic community were identified: low species diversity and limited habitat diversity. Species diversity is extremely low within most reaches of Maline Creek because of the poor water quality. Assuming that water quality conditions improve significantly as a result of Federal and state pollution-control programs, the existing habitats provided by the surface drainage system would still limit the potential for expanded numbers and types of aquatic life. As a result of the above, and in order to improve aquatic conditions within the waterhsed, the primary need is to improve water quality and secondly, to improve aquatic habitats.

23. Terrestrial Communities. Extensive urbanization within the watershed has reduced the amount of undeveloped areas that are the primary habitats for terrestrial wildlife. The need and value of these types of areas have been demonstrated. The 1976 State-wide Comprehensive Outdoor Recreation Plan estimated that 25 percent of the people in this area participate in nature walking and 10 percent in birdwatching. In addition, the Missouri Department of Conservation's Design for Conservation emphasizes the need for wildlife habitat near major population centers. The Design for Conservation also emphasizes the need to preserve wildlife or scenic open spaces such as bluffs, ledge rock areas, and flood plains within small critical watersheds, such as Maline Creek. Consequently, in order to preserve these habitats, a need exists to keep the remaining undeveloped lands undeveloped, particularly those parcels that are not in public ownership and therefore most likely to succumb to development pressures. In addition, a need exists to enhance the habitat already being provided in the developed areas within the watershed.

Formulation of Measures to Resolve Problems, Needs, and Opportunities Related to Fish and Wildlife Resources

24. Summary of Cycles One and Two. The first two formulation cycles resulted in the development of two "polar" plans, one emphasizing a traditional structural flood control plan and one emphasizing a nature-oriented flood control plan. A compromise plan was then developed and recommended as a result of an extensive public involvement program. Recommended measures were generally based on resolution of multiple purposes, including engineering, environmental, and outdoor recreation. Recommended measures that could jointly satisfy fish and wildlife conservation and other purposes included the following:

a. Fifteen miles of gabion-lined channel improvements.

b. Sixty in-channel weirs to create small pools.

c. Acquisition of, or easements on, most undeveloped flood plain acreage that could be managed as wildlife habitat.

d. Two wet reservoirs to be developed as fishing areas.

e. Acquisition of large undeveloped tracts surrounding 14 dry reservoir sites that could be managed as wildlife habitat.

25. Summary of Cycle Three. Initially, the third cycle involved the formulation of single-purpose measures to satisfy flood control, outdoor recreation, and environmental quality purposes. The single-purpose measures were then refined and combined with measures developed for other purposes. Detailed NED, EQ, and recommended plans were developed. Recommended plan measures that could satisfy fish and wildlife conservation purposes, most of which jointly satisfy other purposes, included the following:

a. Aquatic habitat structures to create fish pools in stream reaches M7, M9, and MD1.

b. Fish ponds just downstream from dry detention basins M27, M22, MH-1, MD1-1, and MD2-2.

c. Acquisition and management as wildlife habitat of 300 acres of undeveloped acreage adjacent to dry detention sites MD1, MD2-2, MD1-1, MH1, M22, M27, MF1, MF2, and MB2, and 75 acres of undeveloped flood plain adjacent to stream reaches in the watershed.

26. Summary of Cycle Four. The fourth cycle involved a reformulation of the three fish and wildlife conservation measures mentioned in paragraph 25. The acreage acquired adjacent to the creek was increased, and the stream reaches affected by flood control improvements were changed; these changes were reflected in the fish and wildlife measures. Flood control, outdoor recreation, and fish and wildlife purposes and measures were closely coordinated during this planning cycle, and opportunities to satisfy multiple purposes captured for most measures. Detailed NED and EQ plans were developed. The EQ Plan was selected as the Recommended Plan. Recommended Plan measures that could satisfy fish and wildlife conservation purposes, as well as jointly satisfying other purposes, included the following:

a. Aquatic habitat structures. Aquatic habitat diversity would be enhanced by construction of 18 aquatic habitat structures at approximately 0.5-mile intervals throughout stream reaches M1 through M14 and MD1. A flood control measure of the Recommended Plan required grade control structures in these same locations. The design was modified to provide pools for fish and other aquatic biota while retaining the grade control function. These structures would also satisfy the outdoor recreation purpose, by increasing

fishing and wading opportunities in these stream reaches. The design details of these structures are shown in PLATE E-57.

b. Fish Ponds. Aquatic habitat diversity would be further enhanced by constructing fish ponds immediately downstream from dry detention reservoirs MD1-1, MD2-2, MH1, M22, and M27. The ponds would vary in size from 2 to 4 acres, for a total of 14 surface acres. The ponds would be appropriately stocked to provide fishing opportunities at these sites. A typical perspective of these structures is shown in PLATE E-66.

c. Open space land acquisition and preservation. A total of 858 acres would be purchased in fee for project purposes, 384 at detention sites (including the 14 acres for fish ponds) and 474 along the stream corridor. Most of the undeveloped acreage would be purchased at detention sites MD2-2, MH1, MD1-1, M27, M22, MF1, MB2, MD1, and MF2. Essentially all of the 10-year frequency flood plain would be purchased in stream reaches M1 through M15, MB, MD1, MD2, MD1-1, MD1-2, and MH. A total of 567 acres would be acquired for flood control purposes; 291 additional acres would be acquired for fish and wildlife or outdoor recreation purposes. Regardless of the primary purpose of acquisition, most of this acreage would be jointly used for flood control, outdoor recreation, and fish and wildlife conservation purposes. After project construction, of the total Recommended Plan purchases, 476 acres of undeveloped wildlife habitat would remain. Assurances would be sought from the local sponsors to maintain most of this habitat in its natural condition, particularly in the watersheds of proposed fish ponds.

Mitigation Requirements

27. The potential need for aquatic habitat or wildlife habitat mitigation to compensate for Recommended Plan construction was evaluated in APPENDIX B. It was concluded that no aquatic habitat

or wildlife habitat mitigation would be required. The aquatic habitat structures and fish ponds provide much greater aquatic habitat diversity than would be expected in the future without a project. The 476 acres of undeveloped wildlife habitat remaining after project construction is nearly twice the acreage of undeveloped wildlife habitat that would remain in the future without a project (TABLE B-40).

Assessment of Impacts

28. An assessment of environmental impacts on fish and wildlife resources is given in APPENDIX B. The net environmental effects are given in the Environmental Impact Statement, TABLE 15. A net increase in aquatic habitat diversity is expected. A net beneficial impact on wildlife habitat would be expected, because of the preserved habitat and the construction of fish ponds which would increase the diversity of wildlife habitat.

Endangered Species Assessment

29. An assessment of the potential impacts on endangered species is given in APPENDIX I. The conclusion reached by the Maline Creek study team and verified through consultation with the U.S. Fish and Wildlife Service is that the Maline Creek Recommended Plan would result in no significant effect on endangered species.

MALINE CREEK, MISSOURI

SURVEY REPORT FOR FLOOD CONTROL AND ALLIED PURPOSES

APPENDIX G

SOCIAL AND CULTURAL ASPECTS

APPENDIX G

SOCIAL AND CULTURAL ASPECTS

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MALINE CREEK, MISSOURI

SOCIAL AND CULTURAL ASPECTS

1. The purpose of Appendix G is to provide a concise report on the social and cultural aspects defined in detail elsewhere in this report.

Existing Conditions

2. The existing social and cultural conditions are specified in detail in APPENDIX A. In summary, within the Maline Creek floodplain area, a generalized longstanding degradation of the fundamental quality of life and community cohesion may be in part attributable to flood susceptibility. Recovery from flood inundation is seldom complete, and a remnant fear or potential of future flooding creates an instability and uncertainty that permeates the community. Development is largely limited to the flood prone area since it contains the only remaining significant open space.

Future Conditions Without Project

3. The future conditions without project time frame for this study is 1990 to 2090. Within this time frame, a continuation of the existing history of Maline Creek social and cultural evolution has been forecast. The 1990 to 2090 scenario indicates essentially complete urbanization of the Maline Creek floodplain area outside the 100-year flood limits except for those pockets that may be preserved in dedicated outdoor recreation activities. The St. Louis County Linear Parks Program does provide an opportunity to maintain the existing outdoor recreation amenities and enhance the social and

cultural disposition of the Maline Creek floodplain area. The details of these possibilities are presented in APPENDIX B and APPENDIX F.

Future Conditions with Project

4. Installation of the recommended plan of improvements for Maline Creek, would have a clearly beneficial impact on the social and cultural aspects of the floodplain and surrounding areas. The combined impact of a nearly 90 percent reduction in average annual flood damages plus the outdoor recreation trail, aquatic habitat structures and fish ponds would significantly enhance the study area. The Maline Creek floodplain area, commonly referred to as the Maline Creek "sewer," and looked upon as a detriment to the surrounding communities, would be converted into a real asset to the communities through which it flows. Under the 1990 to 2090 with project conditions, properties adjacent to the floodplain area may enjoy a premium position, rather than their current generally blighted disposition. The details of these considerations are presented in APPENDIX B.

MALINE CREEK, MISSOURI

SURVEY REPORT FOR FLOOD CONTROL
AND ALLIED PURPOSES

APPENDIX H

ECONOMICS

APPENDIX H

ECONOMICS

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FLOOD DAMAGE CALCULATION PROCEDURES

1. As a means of quantifying the magnitude of the flood problem within the Maline Creek watershed for both existing and future without project conditions (see APPENDIX A), selected hydrologic and hydraulic output from HEC-2 and HEC-1, respectively, was used in conjunction with basic economic information in order to estimate the dollar amount of flood damages expected to occur on an average annual basis. The basic procedure used to compute average annual damages involved: locating all flood damageable property; estimating their structural and content values and associated miscellaneous damages; computing total damages; and finally, computing average annual damages. Each of these steps is discussed in turn in the following paragraphs.

Locating Damageable Property

2. The process of determining average annual damages began with field surveys of all residential, commercial, and industrial property within the standard project flood plain boundaries as defined by the hydraulic studies. Each structure was catalogued according to reach, first floor level elevation, type of structure, value of structure, and closest upstream cross section (See TABLE H-1). The economic damage reaches are shown in PLATE H-1. The first floor elevations, in terms of mean sea level (msl), were determined using USGS benchmark elevations, cross section data used for input to HEC-2, and one inch equals 200 feet scale, planimetric maps (1958) with 5-foot contours and property boundaries. The maps were supplied by the MSD in cooperation with the St. Louis County Department of Planning. Discrepancies between elevations on the topographic maps and the surveyed cross sections were resolved by on-the-ground survey crews.

TABLE H-1
MALINE CREEK
SAMPLE CODING FOR STRUCTURE, BY REACH,
VALUE, AND STREAM MILE
ELEVATION DAMAGE WORKSHEET

Reach	M.S.L. Elevation	Type Structure 1/	Value Structure	River Mile
M3	446	18	25,000	1.950
M3	446	18	25,000	1.950
M3	441	01	13,000	2.050
M3	441	01	13,000	2.050
M3	452	13	50,000	2.149
M8	459	13	30,000	4.200
M8	467	13	30,000	4.200
M8	464	13	15,000	4.397
M9	469	13	30,000	4.425
M9	462	10	13,000	4.719
M9	472	13	25,000	4.790
M9	465	01	25,000	4.850
M9	464	13	13,000	4.900
M9	471	13	28,000	4.900
MA	452	13	28,000	.720
MA	460	13	20,000	.720
MD1	455	01	30,000	.610
MD1	465	13	32,000	.610
MD1	458	13	35,000	.610
MD2	460	107	12,000	1.060
MD2	460	115	8,000	1.060
MD2	474	13	18,000	1.225
MD2	456	01	10,000	1.225

1/ See TABLE H-3 for definitions.

Estimating Depth-Damage Values

3. In order to avoid errors in the use of 5-foot contours, field teams were sent out to verify structure elevations with use of hand levels. Each structure was examined and its first floor elevation determined by using the 5-foot contours supplemented with hand level readings and known spot elevations on streets (manhole covers for example), physiographic features, and other locatable benchmarks. Whenever there was doubt, professional surveyors were called upon to provide the needed data.

4. A field survey for the Maline Creek area residential units was accomplished by determining the similarity of its units to that of several local areas that have experienced flooding in the last few years similar in nature to that of Maline Creek (i.e., flash flooding). By surveying these areas, determining their similarity to the Maline Creek area, and interviewing homeowners and examining their damage repair bills for recent floods, the data necessary for developing depth-damage curves which can be used in the Maline Creek area was compiled. Upon survey completion, the data collected and documented by the Corps of Engineers supported the use of the 1974 Federal Insurance Administration (FIA) depth-damage curves in this report. If any discrepancy of significance in these depth-damage curves is discovered under further examination of the local economic base data, corrections will be documented and implemented at that time. The residential structural values were estimated by conferring with local realtors and by using St. Louis County tax assessment information (See TABLE H-2). The structural types were defined for this study consistent with the classifications given in the January 1974 FIA depth-damage tables (TABLES H-3 and H-4). These classifications were used in lieu of simply the "with" or "without" basement classifications in order to more accurately determine the damage incurred by each type of structure. Damages to structures were computed by relating the 1974 FIA depth-damage curves to the elevation of each structure within the SPF flood plain. Structure elevations were obtained by field surveys. A survey of both local homeowner's insurance companies and the State of Missouri Office of Insurance indicates the value of residential unit contents in an urban area is equal to 50 percent of the structural value. Since the Maline Creek flood plain is recognized as urban in nature, content value was equated with 50 percent of the structural value. The resultant figures were then used, along with the damage percentages given in the FIA table, to compute content damage. Contents include furniture, appliances, domestic goods, and fixtures. TABLE H-5 displays content value by structure type for each reach. For this study, miscellaneous damages were computed to be 30 percent of the combined structural and content damages. The

TABLE H-2
MALINE CREEK
AVERAGE RESIDENTIAL STRUCTURE VALUE BY TYPE
STANDARD PROJECT FLOOD PLAIN

Reach	Units (#,$)	Type of Structure By Code 1/ 01	03	05	13	18	23	10
M1	#	84			44			
	$	27,800			31,400			
M2	#				28			
	$				26,700			
M3	#	40			4	8		
	$	13,000			40,000	28,100		
M4	#				64			
	$				35,400			
M6	#	84			233			
	$	11,400			14,100			
M7	#	30			140	1		
	$	15,000			16,700	27,000		
M8	#	143			376	178		
	$	14,000			18,700	20,000		
M9	#				216			
	$				31,300			
M10	#				77	11		
	$				22,600	31,200		
M11	#				108	2		
	$				28,100	17,500		
M12	#				196	37		
	$				25,200	25,900		
M13	#	30			73	4		
	$	17,400			19,800	23,800		
M14	#	93	1		46	2		
	$	16,600	8,000		14,600	18,500		

TABLE H-2 (Continued)
MALINE CREEK
AVERAGE RESIDENTIAL STRUCTURE VALUE BY TYPE
STANDARD PROJECT FLOOD PLAIN

Reach	Units (#,$)	Type of Structure By Code[1/] 01	03	05	13	18	23	10
M15	#	43	2		17			
	$	7,700	12,500		17,400			
M16	#				88	45		
	$				20,600	21,900		
MA	#				54			
	$				25,500			
MB	#				58	7		
	$				28,100	28,000		
MC	#				135			
	$				27,400			
MD1	#	3			90			
	$	30,000			33,900			
MD2	#	80	5		67	8	1	
	$	21,000	14,800		23,500	15,900	15,000	
MD3	#				50			
	$				29,000			
MD4	#	25			30			
	$	28,300			28,900			
MD5	#				71			
	$				28,400			
MD6	#				55			
	$				28,100			
MF1	#	10			25			
	$	17,000			17,100			
MG1	#				19	11		
	$				15,000	15,000		

TABLE H-2 (Continued)
MALINE CREEK
AVERAGE RESIDENTIAL STRUCTURE VALUE BY TYPE
STANDARD PROJECT FLOOD PLAIN

Reach	Units (#,$)	Type of Structure By Code1/ 01	03	05	13	18	23	10
MG2	#				12	7		
	$				15,000	15,000		
MH	#	4			25			
	$	8,000			8,000			
MD1-1	#	9			15			
	$	16,000			28,700			
MD1-2	#	11			51			1
		14,400			18,100			13,000

1/ See Table H-3 for Structure Code Definitions

TABLE H-3
MALINE CREEK
FEDERAL INSURANCE ADMINISTRATION
JANUARY 1974
DEPTH PERCENT DAMAGE
RESIDENTIAL STRUCTURES

First Floor Depth In Feet	One Story-No Basement (01)	Two or More Stories No Basement (03)	One Story With Basement (13)	Two or More Stories With Basement (18)	Split Level No Basement (05)	Split Level With Basement (23)	Mobile Homes (10)
-3			0	0		0	
-2			4	3		3	
-1	0	0	8	5	0	5	0
0	7	5	7	3	3	6	8
1	10	9	18	11	9	16	45
2	14	13	20	17	13	19	64
3	26	18	23	22	25	22	74
4	28	20	28	28	27	27	79
5	29	22	33	33	28	32	80
6	41	24	38	35	33	35	81
7	43	26	44	38	34	36	82
8	44	31	49	40	41	44	82
9	45	36	51	44	43	48	82
10	46	38	53	46	45	50	82
11	47	40	55	48	46	52	82
12	48	42	57	50	47	54	82
13	49	44	59	52	48	56	82
14	50	46	60	54	49	58	82
15	50	47	60	56	50	59	82
16	50	48	60	58	50	60	82
17	50	49	60	59	50	60	82

TABLE H-4
MALINE CREEK
FEDERAL INSURANCE ADMINISTRATION
JANUARY 1974
DEPTH PERCENT DAMAGE
RESIDENTIAL CONTENTS

Depth In Feet	All On First Floor (01)	All On First Two Floors (03,05)	First Floor and Basement (13,23)	First Two Floors and Basement (18)	All In Basement	All Above First floor	Mobile Homes (10)
-4			0	0	0		
-3			5	0	45		
-2	0	0	7	6	50	0	0
-1			8	9	55		
0	10	7	15	11	60	1	3
1	17	9	20	17	60	2	27
2	23	17	22	22	60	3	50
3	29	22	28	28	60	4	65
4	35	28	33	33	60	5	71
5	40	33	39	39	60	6	76
6	45	39	44	44	60	6	78
7	50	44	50	49	60	6	79
8	55	50	55	55	60	6	81
9	60	55	60	61	60	10	83
10	60	58	60	64	60	17	83
11	60	65	60	71	60	23	83
12	60	72	60	76	60	29	83
13	60	78	60	78	60	35	83
14	60	79	60	79	60	40	83
15	60	80	60	80	60	45	83
16	60	81	60	81	60	50	83
17	60	81	60	81	60	55	83
18	60	81	60	81	60	60	83

TABLE H-5
MALINE CREEK
AVERAGE RESIDENTIAL CONTENT VALUE BY TYPE
FOR THE STANDARD PROJECT FLOOD PLAIN

Reach	Type of Structure By Code1/						
	01	03	05	13	18	23	10
M1	13,900			15,700			
M2				13,350			
M3	6,500			20,000	14,050		
M4				17,700			
M6	5,700			7,050			
M7	7,500			8,350	13,500		
M8	7,000			9,350	10,000		
M9				15,650			
M10				11,300	15,600		
M11				14,050	8,750		
M12				12,600	12,950		
M13	8,700			9,900	11,900		
M14	8,300	4,000		7,300	9,250		
M15	3,850	6,250		8,700			
M16				10,300	10,950		
MA				12,750			
MB				14,050	14,000		
MC				13,700			
MD1	15,000			16,950			
MD2	10,500	7,400		11,750	7,950	7,500	
MD3				14,500			
MD4	14,150			14,450			
MD5				14,200			
MD6				14,050			
MF1	8,500			8,550			
MG1				7,500	7,500		
MG2				7,500	7,500		
MH	4,000			4,000			
MD1-1	8,000			14,350			
MD1-2	7,200			9,050			6,500

1/ See TABLE H-3 For Structure Code Definition.

30 percent figure was determined in view of the urban setting and subdivisional nature of the Maline Creek flood plain. The miscellaneous category represents damages to various items which are indigenous to the urban environment. These items include clean-up costs, lost wages, emergency health care, landscape damage, and damages to subdivision facilities, utilities, sewers, streets, and public lands. Individually, the damages to each item are minimal in terms of structural and content damage. However, taken together, they represent a significant portion of the flood damages.

4. Commercial/industrial values were estimated by using St. Louis County tax assessments, private owner insurance appraisals, "Marshall Valuation Appraisal" (Marshall and Swift Publication Company), and onsite field surveys as sources (See TABLES H-6 and H-7). The latter source was used to make individual adjustments not taken into account by the first three sources. TABLES H-8 and H-9 display the commercial/industrial depth-damage figures used.

Computing Total Damages

5. The slopes of the water surface profiles on the different branches of Maline Creek made the total damage computations potentially complex (see APPENDIX D). By using an hydraulic-economic reference point (HERP) and actual mean sea level elevations for each structure, the elevation-damage relationships for each structure within each reach was documented, and the entire reach was shifted to center on the cross section rating curve for each HERP. The data were then prepared in this normalized configuration for input to the St. Louis District's Urban Damage Program which, after inputting a rating curve (elevation-discharge) for each HERP, automatically computes total damages by elevation for

TABLE H-6
MALINE CREEK
AVERAGE COMMERCIAL STRUCTURAL VALUE BY TYPE
STANDARD PROJECT FLOOD PLAIN

Reach	Units # and $	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116
		Type of Structure By Code[1]															
M5	#		1												2		
	$		21,200												200,400		
M6	#					1		1								1	
	$					25,100		35,200								144,500	
M10	#														2		
	$														454,000		
M12	#	1	3			2	2	2	4	2	2	2	2		1	6	
	$	26,700	16,400			39,000	5,900	19,000	28,300	9,400	65,700	10,800	16,200		[illegible]	15,800	
MD1	#																1
	$																595,000
MD2	#			2	1	2	2	1		1	1	1				1	
	$			111,200	107,700	14,900	38,500	12,000		26,900	17,600	45,900				8,000	
MF1	#			1											1	1	
	$			9,700											12,900	27,300	

TABLE H-6 (Continued)
MALINE CREEK
AVERAGE COMMERCIAL STRUCTURAL VALUE BY TYPE
STANDARD PROJECT FLOOD PLAIN

Reach	Units # and $	Type of Structure By Code[1] 101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116
MF2	#																
	$																
MG1	#		2													1	
	$		13,350													37,400	
MG2	#		1				1		1							2	
	$		12,400				5,200		12,600							28,100	
MD1-1	#	1													1	4	
	$	27,500													13,100	308,600	
TOTAL	#	2	7	3	1	5	5	4	5	3	3	3	2	0	7	16	1

[1] See TABLE C-18 for structure code definition. All blank spaces represent zero (0) # or $.

TABLE H-7
MALINE CREEK
AVERAGE COMMERCIAL CONTENT VALUE BY TYPE
STANDARD PROJECT FLOOD PLAIN

Reach	Type of Structure By Code[1]															
	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116
M5		10,600												100,200		
M6					12,550		17,600								72,250	
M10														227,000		
M12	13,350	8,200			19,500	2,950	9,500	14,150	4,700	32,850	5,400	8,100		5,000	7,900	
MO1																297,500
MO2			55,600	53,850	7,450	19,250	6,000		13,450	8,800	22,900				4,000	
MF1			4,850											6,450	13,650	
MF2															18,700	
MG1		6,675													14,050	
MG2		6,200				2,600		6,300						6,550	154,300	
MO1-1		13,750														

[1] See TABLE C-18 for structure code definition. All blank spaces represent zero (0) # or $.

TABLE H-8
MALINE CREEK
DEPTH PERCENT DAMAGE
COMMERCIAL STRUCTURES

First Floor Water Depth In Feet	Structure Type (101) Gas Station	(102) Gas Station Services	(103) Drug Grocery Chain Food	(104) Disc. & Dept. Stores	(105) H'ware, Paint, Auto, Sport Stores	(106) Barber & Beauty Shops	(107) Laundry-Cleaners	(108) Quick Shops, Bakeries	(109) Fast Food, Dairy Queen Etc.	(110) Restaurants & Large Fast Food (McDonald's)	(111) Fashion Shoe Etc.	(112) Liquor Stores, Taverns	(113) Bowling Alleys	(114) Ware-house Storage Bldg.	(115) General Office Space: Doctors, Bank, Etc.	(116) Schools
-4	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
-3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	8	8	8	8	8	8	8	8	8	6	8	10	8	8	8	
1	22	22	22	22	22	22	22	22	22	22	22	24	22	22	22	10
2	30	30	30	30	30	30	30	30	30	30	30	31	30	30	30	16
3	35	35	35	35	35	35	35	35	35	35	35	37	35	35	35	20
4	39	39	39	39	39	39	39	39	39	39	39	41	39	39	39	24
5	41	41	41	41	41	41	41	41	41	41	41	44	41	41	41	27
6	44	44	44	44	44	44	44	44	44	44	44	46	44	44	44	30
7	46	46	46	46	46	46	46	46	46	46	46	48	46	46	46	32
8	48	48	48	48	48	48	48	48	48	48	48	49	48	48	48	34
9	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	39
10	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	42
11	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	45
12	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	47
13	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	49
14	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
15	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
16	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
17	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
18	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50

Source: East St. Louis and Vicinity, Blue Waters Ditch General Design Memorandum, September 1976

TABLE H-9
MALINE CREEK
DEPTH PERCENT DAMAGE
COMMERCIAL CONTENTS

First Floor Water Depth In Feet	(101) Gas Station	(102) Gas Station Services	(103) Drug Grocery Chain Food	(104) Disc. & Dept. Stores	(105) H'ware, Paint, Auto, Sport Stores	(106) Barber & Beauty Shops	(107) Laundry-Cleaners	(108) Quick Shops, Bakeries	(109) Fast Food, Dairy Queen Etc.	(110) Restaurants & Large Fast Food (McDonald's)	(111) Fashion Shoe Etc.	(112) Liquor Stores, Taverns	(113) Bowling Alleys	(114) Ware-house Storage Bldg.	(115) General Office Space: Doctors, Bank, Etc.	(116) Schools
	Structure Type															
-4	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
-3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	14	42	17	3	13	0	0	36	2	6	4	5	20	35	1	1
1	14	58	74	20	48	2	41	107	5	10	26	12	41	152	2	2
2	16	74	97	37	77	3	69	149	8	19	48	19	71	199	3	3
3	25	90	120	41	90	7	87	192	10	25	53	26	89	246	4	4
4	26	96	143	55	105	8	98	235	13	27	72	33	100	293	4	4
5	26	105	165	62	111	9	161	278	15	30	81	38	118	340	5	5
6	26	109	168	63	119	9	161	284	17	34	82	42	118	348	6	6
7	26	112	173	65	123	9	161	290	18	36	84	45	118	355	7	7
8	26	116	176	66	127	9	161	296	21	39	86	53	118	370	7	7
9	26	118	180	68	131	9	161	303	21	39	88	53	118	370	8	8
10	26	120	184	69	131	9	161	308	21	39	89	53	118	378	9	9
11	26	120	184	69	131	9	161	308	21	39	89	53	118	378	9	9
12	26	120	184	69	131	9	161	308	21	39	89	53	118	378	9	9
13	26	120	184	69	131	9	161	308	21	39	89	53	118	378	9	9
14	26	120	184	69	131	9	161	308	21	39	89	53	118	378	9	9
15	26	120	184	69	131	9	161	308	21	39	89	53	118	378	9	9
16	26	120	184	69	131	9	161	308	21	39	89	53	118	378	9	9
17	26	120	184	69	131	9	161	308	21	39	89	53	118	378	9	9
18	26	120	184	69	131	9	161	308	21	39	89	53	118	378	9	9

Source: East St. Louis and Vicinity, Blue Waters Ditch General Design Memorandum, September 1976

TABLE H-10
MALINE CREEK
SAMPLE DAMAGE ELEVATION OUTPUT

Upper End of Economic Reach = 2149

Stream = M
Damage Center = 2050

DC Elevation	438.9	440.1	441.9	442.5	444.0	445.2	446.2	451.5
Residential Values	0.	78.0	520.0	520.0	620.0	695.0	755.0	905.0
Residential Struct.	0.	5.5	49.7	49.7	114.9	145.7	165.6	315.0
Residential Contents	0.	3.9	40.2	40.2	74.8	92.4	109.6	203.3
Residential Misc.	0.	2.8	26.9	26.9	56.9	71.4	82.6	155.5
Residential Damages	0.	12.2	116.8	116.8	246.6	309.5	357.8	673.7
Number Residentials	0	6	40	40	44	47	49	52
Commercial Values	0.	0.	0.	0.	0.	0.	0.	0.
Commercial Struct.	0.	0.	0.	0.	0.	0.	0.	0.
Commercial Contents	0.	0.	0.	0.	0.	0.	0.	0.
Commercial Misc.	0.	0.	0.	0.	0.	0.	0.	0.
Commercial Damages	0.	0.	0.	0.	0.	0.	0.	0.
Number Commercials	0	0	0	0	0	0	0	0

Average Annual Damages = 59.0

each reach. Samples of the input card and output printout are included as TABLE H-10. PLATE H-1 shows the location of the damage reaches.

Average Annual Damage Computation Procedures

6. Given the elevation-damage relationships for each reach, the next step involved converting this information into expected average annual damages. Because of the number of reaches used to calculate total damages and the resultant effort that would be required to plot and planimeter the damage-frequency curves or manually integrating to arrive at average annual damages, this procedures was automated by using the HEC-1 Multi-Plan Program. This program relates discharge-damage and discharge-frequency functions for each reach in order to define the damage-frequency curves. The program then automatically computes the annual damages for specified points in time. A sample printout of the HEC-1 Multi-Plan's economic output is included as TABLE H-11. Details are provided in APPENDIX D.

PLAN FORMULATION ANALYSIS

7. The economic analyses conducted during formulation cycles one, two and three (see APPENDIX B) are contained within the July 1973, January 1974, and March 1978 draft Maline Creek reports, respectively. These reports are on file at the St. Louis District, Corps of Engineers' offices. This portions of the Economic Appendix focuses on the NED and Recommended Plan anaysis conducted for the remaining formulation cycles.

TABLE H-11
MALINE CREEK
SAMPLE HEC-1 MULTI-PLAN OUTPUT
COMPUTATION OF ANNUAL DAMAGES AND BENEFIS

ECON DATA FOR 1817 IDENTIFIED AS 2050

FLOOD DAMAGES FOR STATION 1817 PLAN 1

NO.	FLOW	PROB	SUM	TYPE 1	TYPE 2
1	8379.	.524	22.22	22.22	0.
2	9472.	.224	24.93	24.93	0.
3	12994.	.180	53.24	53.24	0.
4	15841.	.043	16.32	16.32	0.
5	20513.	.019	8.79	8.79	0.
6	25179.	.003	1.37	1.37	0.
7	29127.	.005	2.81	2.81	0.
8	50859.	.002	2.03	2.03	0.
	AVG ANN DMG		131.72	131.72	0.

FLOOD DAMAGES FOR STATION 1817 PLAN 2

NO.	FLOW	PROB	SUM	TYPE 1	TYPE 2
1	7463.	.524	4.21	4.21	0.
2	8384.	.224	5.60	5.60	0.
3	11373.	.180	18.29	18.29	0.
4	13395.	.043	6.31	6.31	0.
5	16882.	.019	4.67	4.67	0.
6	20491.	.003	.79	.79	0.
7	24124.	.005	1.74	1.74	0.
8	44236.	.002	1.54	1.54	0.
	AVG ANN DMG		43.15	43.15	0.
	AVG ANN BFT		88.57	88.57	0.

NED Analysis

8. As shown in APPENDIX B, only 16 plans plus the nonstructural and cycle three draft recommended plans survived the economic and planning screening criteria during formulation cycle four. These plans also demonstrated the greatest net benefits after passing through screening. The following paragraphs describe the search for that plan during cycle four which demonstrated the greatest net benefits. An NED plan was created to address the planning objectives in the way which maximizes net economic benefits. Net economic benefits are maximized when plan scale is optimized and the plan is economically efficient. Scale is optimized when the benefits of the last increment of output for each measure in the plan equals the economic costs of that increment. A plan is economically efficient when the outputs of the plan are achieved in a least cost manner. Alternative measures considered in the formulation of an NED plan are to be evaluated according to the identified economic criteria. However, the design of physical structures must be done according to sound engineering criteria. As is true for all alternatives, fundamental design is based upon the interdisciplinary inputs of the planning team. Because an NED plan must address all planning objectives whose incremental dollar benefits exceed dollar costs, the planning objectives that require mitigation, preservation, or enhancement measures are also included when they are justified.

9. Flood Control. The search for a plan that maximizes net economic benefits during formulation cycle four focused on finding the optimum flood control alternative that met the identified screening criteria. In order to add greater certainty to the search for the optimum, the remaining sixteen plans were analyzed in greater detail in terms of benefits and costs. Benefits were updated and additional significant cost items were added to bring

the plans closer to economic and engineering reality. APPENDIX B provides a summary of the screening accomplished for the 16 best NED plans. The detailed extensive analysis for each of the 16 best NED plans on the basis of each of its 33 individual stream reaches and 15 potential detention sites is available for inspection and review in the Urban Studies Section, St. Louis District, Corps of Engineers. This detailed analysis includes the reach identification, annual damages without improvements, the cost of non-structural components, channel costs, bridge replacements, expected real estate purchases, easements and rights-of-way, annual benefits, and other decision items. Before drawing attention to the optimum NED plan, a discussion of the formulation process leading to the NED plan is appropriate.

10. During the development of the 377 plans in the fourth formulation cycle, screening actions were taken which led to a plan that maximized net benefits. The first of these actions tested the economic viability of all detention sites. TABLE H-12 summarizes the results of the detention site analysis. All detention sites were ranked for each of their alternative outlet sizes and flood storage capacities by order of economic performance. The details of this analysis are available for inspection in the Urban Studies Section, St. Louis District, Corps of Engineers. The final sites (updated for a change in discount rate from 6-7/8 percent to 7-1/8 percent) identified as providing the best economic viability are shown in TABLE H-13. Carried through the fourth (i.e., last) formulation cycle was a nonstructural plan, a "traditional" plan and a "conventional" plan. These additional plans were added to the final decision alternatives even though they did not pass all cycle fourth screening criteria inorder to insure the widest possible array of alternatives be displayed and considered.

TABLE H-12
MALINE CREEK
DETENTION SITE ANALYSIS

Detention Site	Elevation	Outlet[c] Size	Annual[a] Cost ($1000)	Annual[a,b] Benefit ($1000)	Net[a] Benefit ($1000)	BCR
* M27	570	(3)d	$ 73	$ 212	$ 139	2.90
	580	1	96	189	93	1.97
	590	1	165	205	40	1.24
	590	5	168	206	38	1.23
* M22	565	(3)d	40	72	32	1.80
	575	1	55	89	34	1.62
	580	1	76	89	13	1.17
	580	5	78	69	-9	.88
* MH-1	555	3	40	63	23	1.58
	565	(1)d	57	110	53	1.93
	570	1	72	111	39	1.54
	570	5	74	44	-30	.59
* MF-1	540	3	38	39	1	1.03
	560	(1)d	75	79	4	1.05
	570	1	108	84	-24	.78
	570	5	112	55	-57	.49
* MF-2	520	3	95	17	-38	.31
	527	1	62	55	-7	.89
	530	(1)d	66	78	12	1.18
	530	5	68	21	-47	.31
M-13	490	3	75	52	-23	.69
	500	1	95	56	-39	.59
	510	1	155	73	-82	.47
	510	5	158	54	-104	.34
MD-1	505	3	64	12	-52	.19
	510	1	77	32	-45	.42
	510	(5)d	78	73	-5	.94
* MD2-2	545	(3)d	54	58	4	1.07
	555	1	69	64	-5	.93
	560	1	89	68	-21	.76
	560	5	93	54	-39	.58
MD-2	500	3	25	3	-22	.12
	510	1	45	21	-24	.47
	515	1	63	21	-42	.33
	515	5	65	2	-63	.03
MD1-1	530	(3)d	77	80	3	1.04
	540	1	99	85	-14	.86
	550	1	153	90	-63	.59
	550	5	155	74	-81	.48

TABLE H-12 (Continued)
MALINE CREEK
DETENTION SITE ANALYSIS

Detention Site	Elevation	Outlet[c] Size	Annual[a] Cost ($1000)	Annual[a,b] Benefit ($1000)	Net[a] Benefit ($1000)	BCR
MD1-2	525	3	33	18	-15	.55
	535	1	53	28	-25	.53
	545	1	89	29	-60	.33
	545	5	90	18	-72	.20
MC-1	510	3	41	9	-32	.22
	515	1	56	13	-43	.23
	520	1	72	13	-59	.18
	520	5	75	8	-67	.11
MC-2	485	3	36	23	-13	.64
	495	1	61	24	-37	.39
	505	1	113	34	-79	.30
	505	5	114	31	-83	.27
MB-1	485	3	51	8	-43	.16
	495	1	72	10	-62	.14
	505	1	121	11	-110	.09
	[illegible]	5	124	8	-116	.06
MB-2	465	3	30	2	-28	.07
	470	1	39	9	-30	.23
	480	1	59	9	-50	.15
	490	5	60	3	-57	.05

[a]All figures are in thousands of dollars. Interest rate = 6-7/8% (.06875).
[b]Benefits computed on a first-added basis.
[c]Low level outlets of diameters, 2, 3, 4, 4.5, 5, 5.5, 6, 7 and 8 feet correspond to outlet size numbers 1-9, respectively.
[d]Detention sites chosen as most useful.
*Has at least one dam/outlet configuration that is justified.

AD-A140 671 WATER RESOURCES INVESTIGATION ST LOUIS METROPOLITAN AREA MISSOURI AND ILL..(U) ARMY ENGINEER DISTRICT ST LOUIS MO SEP 80 7/7

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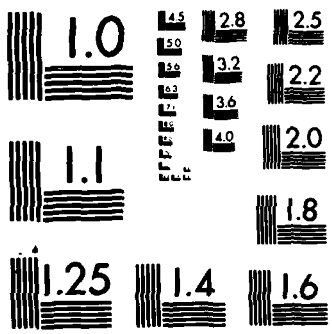


MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

TABLE H-13

ECONOMICALLY FEASIBLE DETENTION SITES

7-1/8%

Detention Site	Top of Dam Elevation	Outlet Size	Annual Cost ($1000)	Annual Benefit ($1000)	Net Benefit ($1000)	BCR
M27	572	3	$ 75	$212	$137	2.83
M22	567	3	41	72	31	1.76
MH-1	567	1	59	110	51	1.86
MF-1	552	1	77	79	2	1.03
MF-2	532	1	68	78	10	1.15
MD-1	512	5	80	73	-7	.91
MD2-2	547	3	56	58	2	1.04
MD1-1	532	3	79	80	1	1.01
			$535	$762	$227	1.42

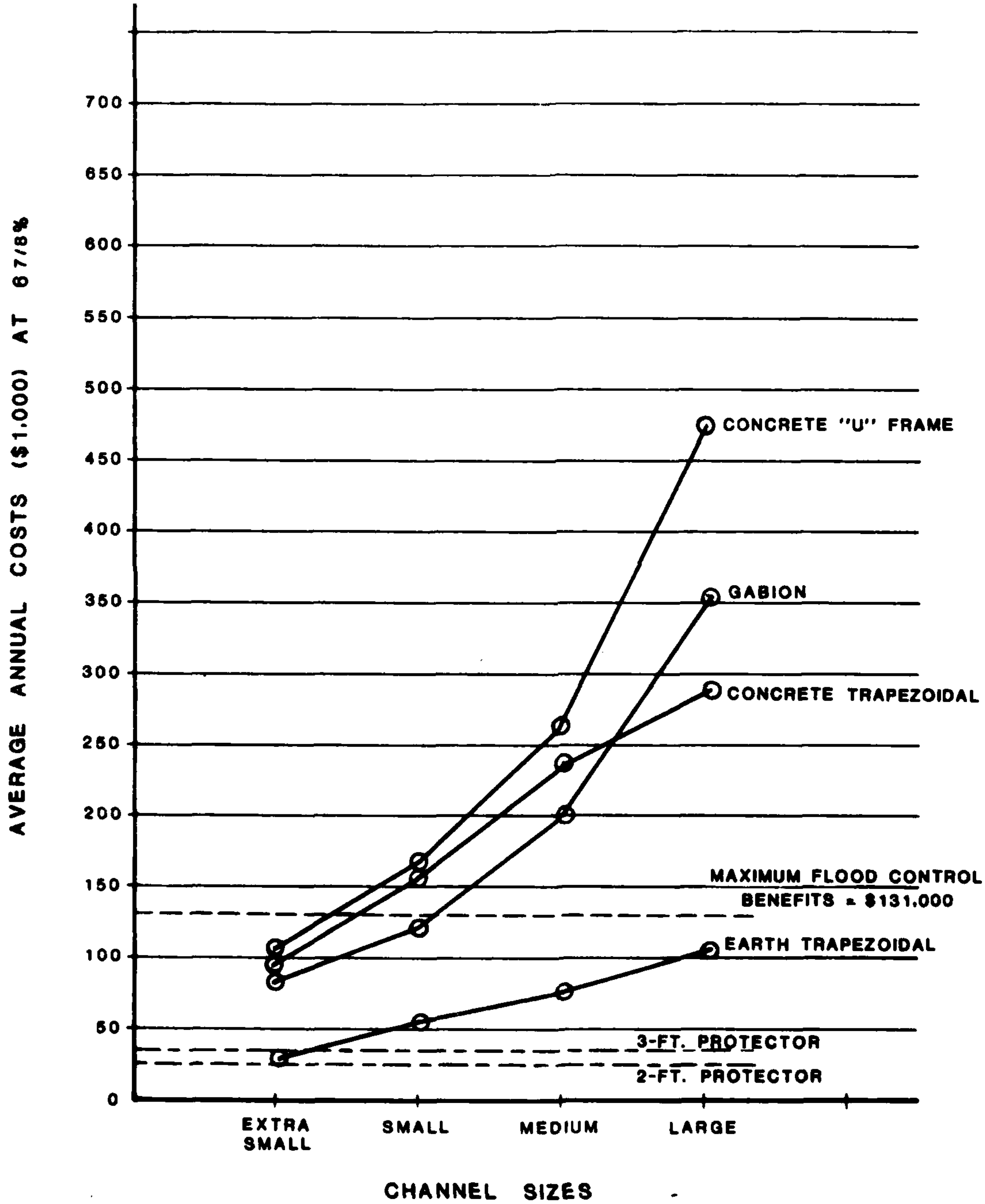
11. Notice that only one detention site (MD-1) does not have a BCR equal to or greater than 1.00. This detention site was retained because of its impact not only on the volume of flood waters it stored, but also due to its beneficial downstream impacts on hydrograph timing. If MD-1 were removed from the system induced damages would result. In other words, each detention site was initially tested incrementally - acting on its own - without other detentions, channel improvements, bridge removals, or non-structural measures. Based on this "independent" approach all but one of the sites (MD-1) added net benefits. Acting as part of a system, MD-1 becomes economically justified because removal of MD-1 from the remaining sixteen system plans would cause induced damages. The system of eight detentions has a BCR of 1.42 with $227,000 of net benefits. The addition of any other site would add more to annual costs than to annual benefits and the removal of any of these eight sites would detract from benefits to a greater extent than from costs.

12. Once having resolved the economics of detention sites, a search for channel and non-structural improvements took place. The thrust of this search initially centered on finding the least costly alternatives. An exhaustive analysis proved that detentions and a wide mix of channel improvements resulted in plans with BCR's less than 1.00 or did not satisfy stated goals, objectives, and constraints. Channel costs almost always exceeded possible benefits. Figure H-1 illustrates for a typical stream reach (i.e., M-16) how it was possible to overcome the cost problem.

13. The horizontal axis in Figure H-1 shows the different size channel improvements available for testing: extra small, small, medium, and large. The vertical axis shows the average annual costs. A plot was made of the cost of each channel size and its associated design: concrete "U" frame, gabion, concrete trapezoidal, and earth trapezoidal. Also, for example purposes, a plot was made of the maximum potential average annual flood damages experienced by reach M16. That is, if M16 were protected 100 percent, the maximum average annual flood control benefits would be $131,000. Notice, that with the exception of earth trapezoidal, all medium and large channels would result in annual costs exceeding annual benefits. This same problem was experienced in all but a few of the other stream reaches. The cost of the measure which could prevent or reduce flood damages was often greater than the total flood damages. As the example of reach M16 shows, this could never lead to a plan with net positive benefits. In fact, 18 of the 33 reaches were unable to economically support channel improvements, and five of the 33 reaches were able to economically justify only very limited channel improvements. Similarly, it was learned that only 10 stream reaches out of 33 were able to economically justify a range of channel improvement sizes and types.

FIGURE H-1

EXAMPLE OF COST AND BENEFIT COMPARISONS IN SEARCH OF LEAST COST SOLUTIONS (REACH M 16)



14. An examination of the concepts behind flood control solutions led to consideration of more recent flood protection concepts - one is called a low level protector. Previous ideas about flood control solutions included constructing small berms around individual homes located in flood prone areas. This concept was expanded to include low level berms around larger aggregates of homes - say 50 or 100 at one time. The low level flood protection is exactly this - a two or three-foot continuous ring berm circumscribing a number of homes and tying to high ground at each end. The low level flood protector would not in-and-of itself stop all flood damages but was used in combination with detention and channel improvements contain the 10-year flood flows and to provide increased economically justified flood protection levels. It provides a community service by reducing frequent nuisance flooding in select areas. An example of cost of a low level flood protector 2 to 3 feet high for a typical reach is shown in Figure H-1. Note for comparison that the protector is far less costly than most channel modifications and would serve to either replace or reduce the size of channel improvements in many reaches. The detentions and channel modifications did most of the work in lowering flood profiles and the low level flood protectors completed the job by preventing damages from frequent nuisance flooding. As modified and used for the control of flows, the protectors are considered structural.

15. The benefits and costs of using detentions, channel improvements, low level flood protectors, and bridge replacements are summarized below in TABLE H-14:

TABLE H-14
SUMMARY OF NED CANDIDATES
COSTS AND BENEFITS (7-1/8%)

Plan	Annual Benefits ($1,000)	Annual Costs ($1,000)	Net Benefits ($1,000)	BCR
50.6	$3,355	$2,505	$ 850	1.34
50.7	3,463	2,580	882	1.34
52.7	2,848	2,206	- 642	1.29

TABLE H-14 (Continued)
SUMMARY OF NED CANDIDATES
COSTS AND BENEFITS (7-1/8%)

Plan	Annual Benefits ($1,000)	Annual Costs ($1,000)	Net Benefits ($1,000)	BCR
63.7	2,836	2,239	600	1.27
72.2	3,372	2,473	899	1.36
72.3	3,334	2,469	865	1.35
72.4	3,344	2,462	882	1.36
72.5	3,324	2,462	862	1.35
72.6	3,333	2,462	871	1.35
72.9	3,346	2,469	877	1.36
74.2	3,700	2,711	989	1.36
74.5	3,674	2,945	729	1.25
74.6	3,649	2,677	972	1.36
78.2	3,841	3,122	719	1.23
78.3	3,822	2,673	1,149	1.43
78.4	3,775	2,755	1,020	1.37

The data indicate that plan 78.3 maximizes net economic flood control benefits. It was therefore designated as the NED plan. The recommended plan is among the NED candidates. Detailed benefits and associated costs for all plans are given in TABLE H-15.

16. The average annual costs and benefits of all 16 NED plans were plotted in Figure H-2. Standard optimization techniques require that the derivitive of the total production function be set equal to one and solved for the dependent and independent variables:

Production Function:

$$Y = -9783.1780 + 8.9955395\ x - 0.0014870486\ X^2;\ r^2 = 0.95$$

TABLE H-15

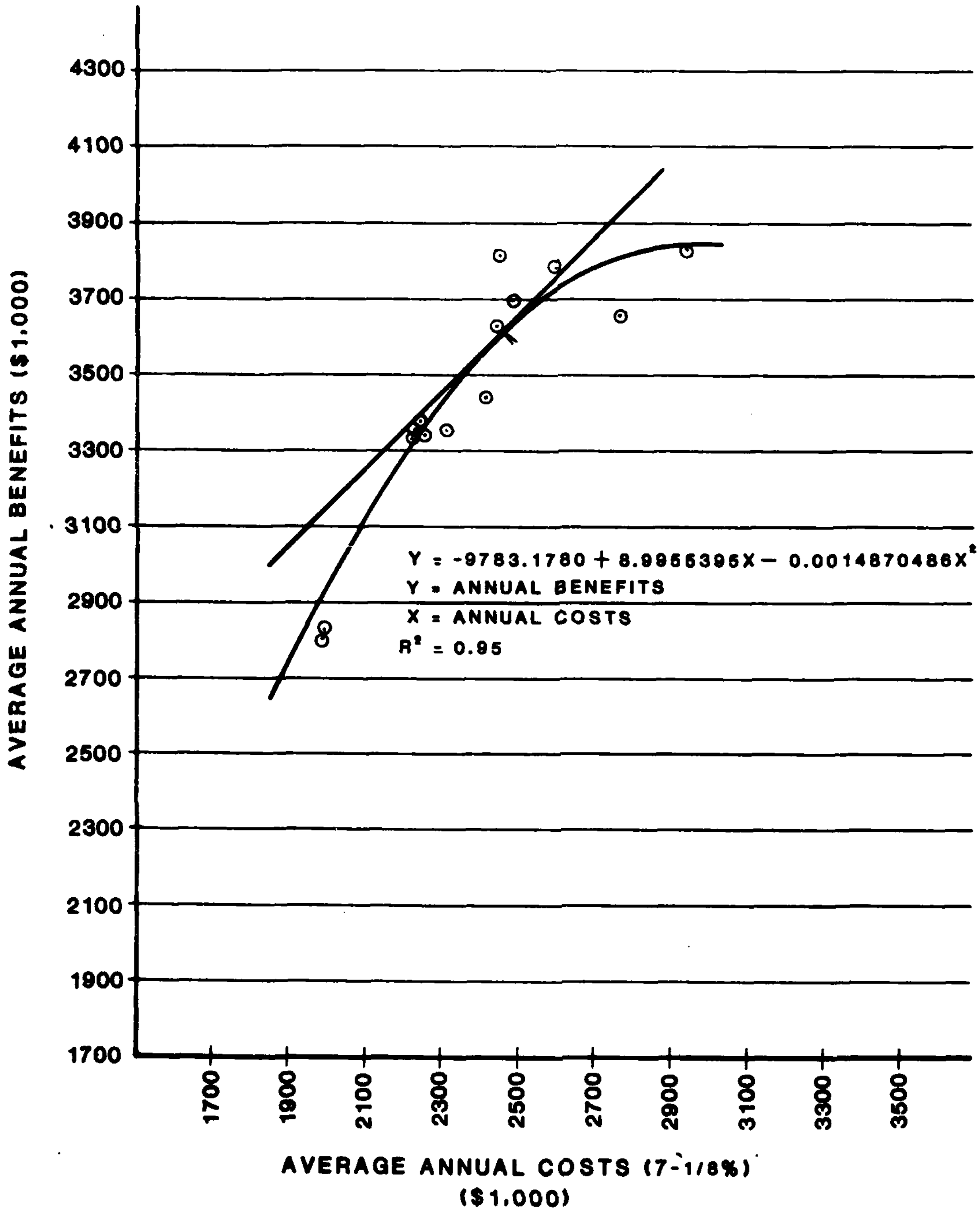
ECONOMIC PERFORMANCE OF FINAL NED CANDIDATES

7-1/8%

	50.6	50.7	52.7	63.7	72.2	72.3	72.4	72.5	72.6	72.9	74.2	74.5	74.6	78.2	78.3	78.4
Annual Costs ($1000)																
Protectors	602	691	626	612	572	568	561	561	561	568	758	758	758	846	840	840
Channels	309	309	0	95	309	309	309	309	309	309	344	575	309	666	206	298
Bridges	275	275	275	243	275	275	275	275	275	275	275	275	275	275	275	275
Buyouts	359	349	349	327	359	359	359	359	359	359	359	359	359	359	365	359
Easement/Right-of-Way	59	56	56	62	57	57	57	57	57	57	75	75	75	81	86	82
Detention	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500
Total Costs	2104	2180	1806	1839	2072	2068	2061	2061	2061	2068	2311	2542	2276	2721	2272	2354
Other Costs 1/	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400
Total Costs	2504	2580	2206	2239	2472	2468	2461	2461	2461	2468	2711	2942	2676	3121	2672	2754
Annual Benefits ($1000)	3355	3463	2848	2836	3372	3334	3344	3324	3333	3346	3700	3674	3649	3841	3822	3775
Net Benefits ($1000)	851	883	642	597	900	866	883	863	872	878	989	732	973	720	1150	1021
Benefit to Cost Ratio	1.33	1.34	1.29	1.27	1.36	1.35	1.36	1.35	1.35	1.36	1.36	1.25	1.36	1.23	1.43	1.37
Percent Damage Reduction	81	82	68	68	81	80	81	81	80	81	89	89	88	92	91	90

1/ Costs include sewer outfalls and interior drainage system.

FIGURE H-2
FLOOD CONTROL NED CANDIDATES



where:

Y = Average Annual Benefits

X = Average Annual Costs

$$\frac{dy}{dx} = 8.9955395 - 0.00297906\ X = 1.0$$

and

X = $2,688,400

Y = $3,652,800

Thus, alternative 78.3 was confirmed as being the plan that maximizes net tangible flood control benefits.

17. The search for a plan which maximizes net economic benefits thus far focused on flood control. This was done to confirm that flood control can stand on its own in terms of benefits and costs. A true optimal plan must include all benefits and all costs. To accomplish this, the data was refined to reflect greater detail. The following paragraphs complete the analysis and identify the final optimum plan.

18. Recreation/Environment. In addition to flood control benefits and costs, the final 16 NED candidates contained recreation and associated environmental benefits and costs. The following basic information was used to evaluate recreation and environmental benefits.

19. The activity day-use and benefit values were evaluated for local applicablilty. Outdoor recreation activity was uniformly

valued at $1.75 per visitor-day. The lengths of flood plain trails included 5.49 miles in reaches M6 to M16, 0.41 miles in tributary MB, 0.47 miles in tributary MD1, and 0.43 miles in tributary MH1. The flood plain trail activities were based on 9,000 biking visitations per mile of trail (annually) and 7,040 hiking visitations per mile of trail (annually). An investigation into the flood control components of each of the final NED candidates indicated modest variability in terms of channel sizes, low level protectors, and bridge removals. These variations did not affect either the recreation or environmental benefits and costs. In other words, the overall recreation scheme was largely unaffected by the variations in and among the alternatives. The benefits and costs are the same. The same detentions, trails, fisheries, picnicking, etc., are apparent to all sixteen candidates. TABLE H-16 illustrates the details of the recreation-environmental benefit analysis. This information is refined upon addressing the details of the recommended plan.

20. Redevelopment. There are no redevelopment (employment) benefits applicable to the Maline Creek study area. Neither St. Louis County nor the city of St. Louis are category 1 areas.

TABLE H-16
MALINE CREEK
ESTIMATED EQ-REC TANGIBLE BENEFITS ($1000)
NOTE: THESE VALUES WERE SUBSEQUENTLY UPDATED IN LATER ITERATIONS, SEE TABLE H-20

ITEM	FISHERIES	GROUP CAMPING	BICYCLING	NATURE WALKS	GAME FIELDS	PICNICKING	TOTAL ANNUAL BENEFITS
A. DETENTION SITES							
M27	$ 0*	$ 0	$ 24	$ 18	$ 42	$ 59	$ 143
M22	0*	0	24	18	32	22	96
MH1	0*	0	21	16	53	62	152
MF1	0	0	0	6	0	29	35
MF2	0	0	6	4	21	29	60
MD1	0	0	4	3	21	29	57
MD2-2	0*	5	0	19	0	59	83
MD1-1	0*	0	16	12	32	59	119
SUBTOTAL	$ 0	$ 5	$ 95	$ 96	$ 201	$ 348	$ 745
B. FLOOD PLAIN TRAIL							
M6 to M-16	$ 1	$ 0	$ 86	$ 68	$ 0	$ 0	$ 155
MB	0	0	6	5	0	0	11
MD1	1	0	7	6	0	0	14
MH1	0	0	7	5	0	0	12
SUBTOTAL	$ 2	$ 0	$ 106	$ 84	$ 0	$ 0	$ 192
C. RAILROAD RIGHT-OF-WAY	$ 0	$ 0	$ 0	$ 0	$ 0	$ 0	$ 0
D. TOTAL AVERAGE ANNUAL BENEFITS	$ 2	$ 5	$ 201	$ 180	$ 201	$ 348	$ 937

*Less than $500 average annual benefits.

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H-32

21. Summary. TABLE H-17 provides refined information on all benefits and costs for each NED candidate. Figure H-3 shows the graphical plot of these data. This plot shows that with the added recreation-environmental data the relationship between the plans was altered somewhat but the overall curve form is similar to that found for flood control alone. Plan 78.3 produced the highest net benefits and became the designated NED candidate.

As before:

Production Function

$$Y = -16448.600 + 12.277465\ X - 0.0017768320\ X^2, \quad r^2 = 0.95$$

where:

Y = Average Annual Benefits

X = Average Annual Benefits

$$\frac{dy}{dx} = 12.277465 - 0.003553664\ X = 1.0$$

and

X = \$3,173,500
Y = \$4,619,200

FIGURE H-3

OVERALL NED PLAN FORMATION

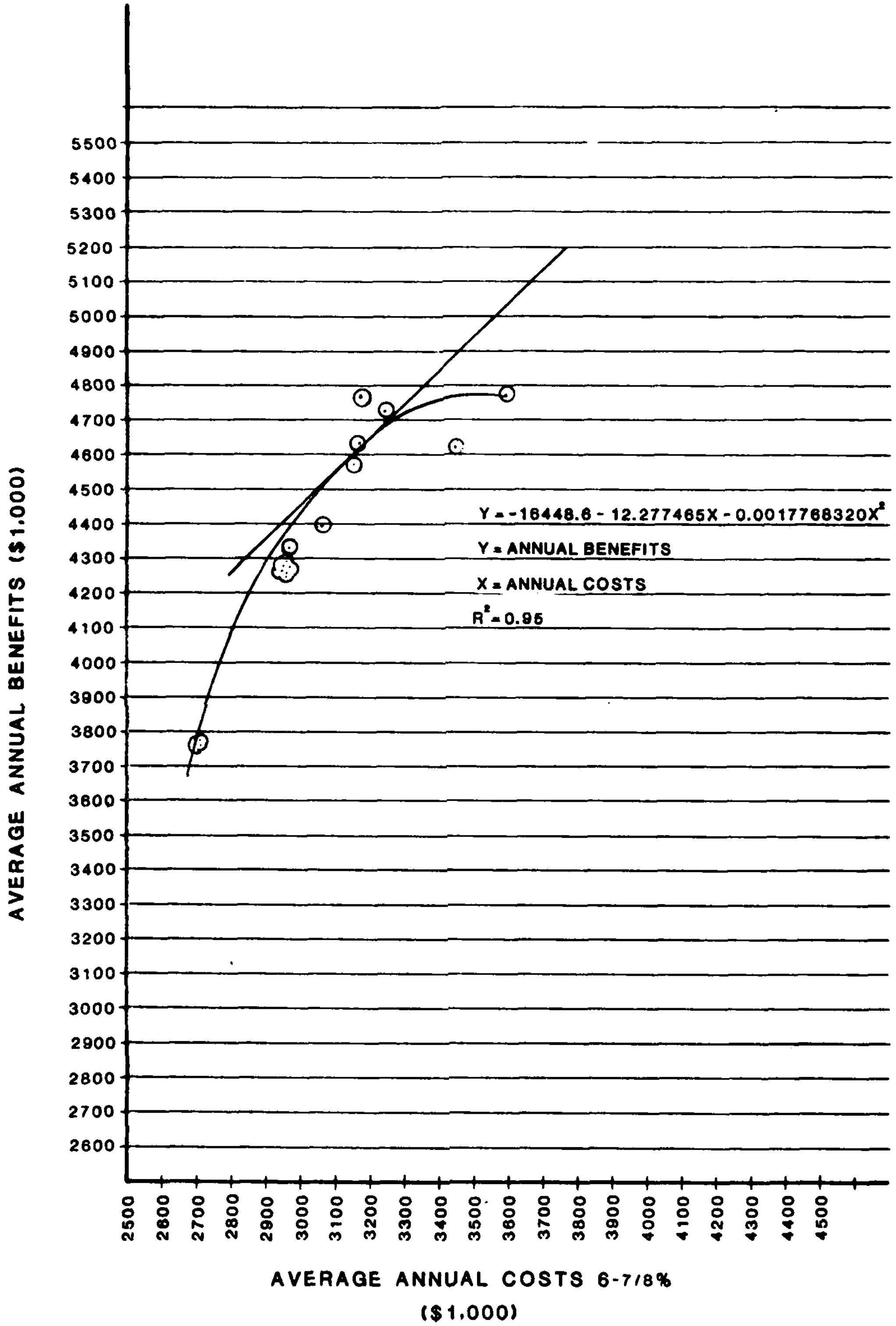

TABLE H-17
NED PLAN FORMULATION
TOTAL AVERAGE ANNUAL BENEFITS AND COSTS
7-1/8% OCT 79 PRICE LEVELS ($1000)

Plan	Flood Control Benefits	Rec/EQ Benefits	Total Benefits	Flood Control Costs	Rec/EQ Costs	Total Costs	BCR	Net Benefits
50.6	$3,355	$ 937	$4,292	$2,505	$470.1	$2,975.1	1.44	$1,316.9
50.7	3,463	937	4,400	2,581	470.1	3,051.1	1.44	1,348.9
52.7	2,848	937	3,785	2,206	470.1	2,676.1	1.41	1,108.9
63.7	2,836	937	3,773	2,239	470.1	2,709.1	1.39	1,063.9
72.2	3,372	937	4,309	2,473	470.1	2,943.1	1.46	1,365.9
72.3	3,334	937	4,271	2,469	470.1	2,939.1	1.45	1,331.9
72.4	3,344	937	4,281	2,462	470.1	2,932.1	1.46	1,348.9
72.5	3,324	937	4,261	2,462	470.1	2,932.1	1.45	1,328.9
72.6	3,333	937	4,270	2,462	470.1	2,932.1	1.46	1,337.9
72.9	3,346	937	4,283	2,469	470.1	2,939.1	1.46	1,343.9
74.2	3,700	937	4,637	2,711	470.1	3,181.1	1.46	1,455.9
74.5	3,674	937	4,611	2,945	470.1	3,415.1	1.35	1,195.9
74.6	3,649	937	4,586	2,677	470.1	2,145.1	1.46	1,438.9
78.2	3,841	937	4,778	3,122	470.1	3,592.1	1.33	1,185.9
78.3	3,822	937	4,759	2,673	470.1	3,143.1	1.51	1,615.9
78.4	3,775	937	4,712	2,755	470.1	3,225.1	1.46	1,486.9

Shown below are the updated NED and EQ plans (78.3 and 78.2 respectively) from subsequently more detailed iterations:

78.2	3,753	1,059	4,812	2,997	577	3,574	1.35	1,238
78.3	3,704	1,059	4,763	2,889	435	3,324	1.43	1,439

1/Subsequent analysis determined that Federal first cost had increased as did O&M. Also recreation benefits and the discount rate increase. Since this happened to all plans, the selection of the NED Plan was not effected.

Economic Analysis of the Recommended Plan

22. The rationale for choosing plan 78.2 over plan 78.3 as the recommended plan during formulation cycle four is thoroughly described in APPENDIX B. Briefly, the reason was that plan 78.2 performs better in terms of damage reductions at the 50, 100, and SPF events. Consequently the trade-off was to reduce the "sting" of larger floods and accept a somewhat less efficient plan in return. For this reason, the remainder of this appendix focuses on the Recommend Plan: 78.2.

23. Economic Performance. TABLE H-18 illustrates the refined details of the economic performance of the recommended plan in terms of flood control aspects.

24. Column 1 identifies the 33 channel reaches.

25. Column 2 shows the amount of average annual damages with any improvements. Total "no plan" average annual damages amounts to $4,145,000. These damages include:

(1) Damages to residences, their contents, and miscellaneous
(2) Commercial damages, their contents, and miscellaneous
(3) Industrial damages, their contents, and miscellaneous
(4) Public structures, their contents, and miscellaneous

TABLE H-18
DETAILS OF THE RECOMMENDED PLAN
OCT 79 PL 7-1/8% $43,800,000

Reach	No Plan Damages ($1000)	Gross FC Benefits ($1000)	Relocate ($1000)	Residual ($1000)	Induced ($1000)	Net FC Control ($1000)	Level of Protection Frequency	Structures Relocated	Measures Used to Achieve Performance1/
M16	131	123	3	3	0	117	25	7	SC
M15	20	19	0	0	0	19	10	-	SC & levee
MH	35	34	2	1	0	31	10	15	SC & levee
M14	70	66	0	2	0	64	25	2	SC & levee
M13	94	90	3	1	0	86	10	6	SEC & levee
M12	615	573	1	6	0	566	10	13 2/	SEC & levee
MG2	530	520	0	5	1	514	10	-	No measure (Brg)
MG1	18	14	0	0	T	14	10	-	No measure
MF2	6	1	0	0	0	1	2	-	No measure
MF1	3	1	0	0	0	1	5	-	No measure
M11	314	298	0	8	0	290	25	-	SC
M10	219	195	0	4	0	191	10	-	MEC & levee & Brg
M9	99	85	0	2	0	83	10	-	Brg & levee
M8	395	389	0	8	0	381	10	-	MEC & Brg
M7	7	3	0	0	0	3	10	-	Levee
M6	197	187	0	4	0	183	10	-	MEC & Brg & levee
MD6	14	3	0	0	0	3	2	-	No measure
MD5	47	37	0	0	0	37	25	-	SC & levee
MD4	35	17	0	0	0	17	2	-	No measure
MD3	51	46	0	1	0	45	10	-	SC & levee
MD1-3	0	0	0	0	0	0	0	-	No damages
MD1-2	55	54	14	0	0	40	25	26	SC & levee
MD1-1	4	2	2	0	0	0	2	3	SC
MD2	136	124	1	1	0	122	10	2	SC & levee
MD1	24	7	0	0	0	7	2	-	No measure

TABLE H-18
DETAILS OF THE RECOMMENDED PLAN
OCT 79 PL 7-1/8% $43,800,000

Reach	No Plan Damages ($1000)	Gross FC Benefits ($1000)	Relocate ($1000)	Residual ($1000)	Induced ($1000)	Net FC Control ($1000)	Level of Protection Frequency	Structures Relocated	Measures Used to Achieve Performance1/
M5	594	[illegible]	0	6	T	572	10	-	MEC & levee
M4	68	[illegible]	0	1	0	56	10	-	Levee
MC	121	[illegible]	0	3	0	97	10	-	SEC
M3	67	[illegible]	0	1	0	60	10	-	Levee
MB	22	[illegible]	0	0	0	19	10	-	No measure
M2	26	22	0	0	0	22	10	-	Levee
MA	89	89	0	5	0	84	500	-	Brg
M1	39	29	0	1	T	28	50	-	SC & levee & Brg
TOTALS	4145	3843	26	63	1	3753	N/A	74	
NED PLAN	4145	3825	40	80	1	3704	N/A	79	

1/ Plus 8 dry detentions, SC is Selective Clearing, levee is levee or wall, SEC is Small Earth Channel, Brg is bridge removal, MED is Medium Earth Channel.
2/ 12 residences and 1 commercial.

26. Column 3 shows gross benefits not yet adjusted for residuals, reduced damages, or relocations. The values are in millions of average annual dollars.

27. Column 4 is gross benefits adjusted for relocations or fee simple purchases. Structures which would be purchased for construction easements and rights-of-way as well as nonstructural damage reductions would no longer experience flood damages. Their damage value was deducted from gross benefits to account for structural removal.

28. Column 5 illustrates the amount of residual damages. These would be damages remaining in the protected reach. They include such items as damages to roads, sidewals, emergency preparedness, clean-up and other miscellaneous items.

29. Column 6 represents the value of induced damages caused by the profile modifications of Maline Creek and tributaries.

30. Column 7 provides the net flood control benefits adjusted for relocations, residual damages, and induced damages. Net flood control benefits would amount to $3,753,000 and account for nearly 90 percent of damage reductions.

31. Column 8 shows remaining average annual damages. These are the damages which cannot be reduced for benefit-costs reasons. They

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represent damages which are expected to occur above and beyond protection.

32. Column 9 depicts the percent average annual damage reduction.

33. Column 10 provides information on the level of protection that would be afforded each reach. All protected and most unprotected reaches would have at least a 10-year level of protection. The following is a summary of levels of protections.

Levels of Protection	No. of Reaches	
500-year	1	3.0%
100-year	1	3.0%
50-year	1	3.0%
25-year	4	12.1%
20-year	1	3.0%
10-year	19	57.6%
5-year	1	3.0%
2-year	1	3.0%
less than 2-year	4	12.1%
	33	100%

The data indicate that about 82 percent of the 33 reaches would receive at least 10-year levels of protection.

34. Column 11 shows the number of structures that would be purchased in fee simple and removed from the now protected flood plain. There would be a total of 74 structures removed.

35. Column 12 shows what action would be taken to prevent the indicated damages. Measures include structural and nonstructural components, clear/snag, brush hogging, eight dry detentions, low level protectors, earth channels, and bridge replacements. The following table (TABLE H-19) shows which reaches would not receive protection:

TABLE H-19

UNPROTECTED REACHES

Reach	Rationale
MG2	97% damage reduction without improvements
MG1	73.3% damage reduction without improvements
MF2	$6,000 annual damages - no cost effective measure
MF1	$3,000 annual damages - no cost effective measure
MD6	$14,000 annual damages - no cost effective measure
MD4	$35,000 annual damages - no cost effective measure
MD1-1	$4,000 annual damages - no cost effective measure
MD1	$24,000 annual damages - no cost effective measure
MB	$22,000 annual damages - no cost effective measure

36. Even though these reaches receive no protective measure, damages would be reduced in all of them as a result of improvements elsewhere.

37. The previous description presented only flood control information. As the study progressed, greater detail was possible and TABLE H-20 shows the final recreation benefit/cost values.

TABLE H-20 MALINE CREEK - EQ/REC, BENEFITS AND COSTS 1/ 7-1/8% OCT 79 PRICE LEVELS ($1,000)

Item	Fisheries	Group Camping	Bicycling	Nature Walks	Game Fields	Picnicking	Annual Benefits	Annual Cost	BCR
A. Detention Sites (*Less than $500)									
M27	$ 0*	$ 0	$ 24	$ 18	$ 42	$ 59	$ 143,000	$ 49,400	2.89
M22	0*	0	24	18	32	22	96,000	43,506	2.21
MH1	0*	0	21	16	53	62	152,000	35,100	4.23
MF1	0	0	0	6	0	29	35,000	33,800	1.04
MD1	0	0	4	3	21	29	59,000	15,900	3.71
MD2-2	0*	5	0	19	0	59	83,000	26,900	3.09
MD1-1	0*	0	16	12	32	59	119,000	30,000	3.97
MB2	0	0	4	3	21	29	57,000	35,100	1.62
	$ 0	$ 5	$ 93	$ 95	$201	$348	$ 742,000	$269,700	2.75
B. Flood Plain Trail									
M1- M14	$10	$ 0	$104	$ 81	$ 0	$ 0	$ 195,000	$ -	-
M15	0	0	5	4	0	0	9,000	-	-
MB	0	0	14	11	0	0	25,000	-	-
MD1	1	0	16	13	0	0	30,000	-	-
MD2	0	0	7	5	0	0	12,000	-	-
MD1-1- MD1-2	0	0	16	12	0	0	28,000	-	-
MH-MH1	0	0	10	8	0	0	18,000	-	-
	$11	$ 0	$172	$143	$ 0	$ 0	$ 317,000	$ 62,700	5.06
TOTAL AVERAGE ANNUAL BENEFITS									
	$11	$ 5	$265	$229	$201	$348	$1,059,000	$332,400 99,800 EQ Features $144,600	 1.84

1/ Data hereon are an updating of the information from Table B-38 and H-16 with new recreation features added.

R 3/17/82 H-42

38. Notice that the dry detention sites are incrementally justified and justfied as a system. The overall BCR for detentions is 2.75. Also notice that no incremental analysis was conducted for the recreation flood plain trail. It did not seem appropriate to break trails into artificial segments for incremental investigations. A trail is a continuous path - not a disjointed increment. As a system, the BCR for trails is 5.06. The BCR for both trails and dry detentions including O&M is a solid 1.84.

39. Total economic performance for the recommended plan is given in TABLE H-21. For flood control alone, the BCR is 1.27. For EQ and recreation alone, the BCR is 1.84. The entire plain including all benefits and costs has a BCR of 1.36. The information represents a careful effort to reduce costs and maximize claimable benefits in a detailed accounting.

TABLE H-21

SUMMARY OF BENEFITS & COSTS FOR THE RECOMMENDED PLAN

7-1/8% OCT 79 PRICE LEVELS

Benefit Category	Average Annual Benefits	Average Annual Costs	BCR	Net Benefits
Flood Control	$3,753,000	$2,997,000 1/	1.25	$ 756,000
Recreation/EQ	1,059,000	577,000 2/	1.84	482,000
TOTALS	$4,812,000	$3,574,000	1.35	$1,238,000

1/ Includes $306,000 flood control share of O&M costs.

2/ Includes $144,000 rec/EQ share of O&M costs.

R 3/17/82

40. Remaining Damages. Since the recommended plan would provide less than SPF or 100-year flood protection, an analysis of remaining damages is appropriate. TABLE H-22 below summarizes average annual remaining damages by reach.

TABLE H-22

AVERAGE ANNUAL REMAINING DAMAGES

($1000)

Reach	Average Annual Remaining Damages
M16	$ 13.3
M15	1.4
MH	5.1
M14	6.6
M13	7.7
M12	48.9
MG2	15.8
MG1	4.8
MF2	5.1
MF1	2.1
M11	56.9
M10	29.8
M9	15.7
M8	13.8
M7	4.1
M6	13.7
MD6	11.1
MD5	10.4
MD4	18.2
MD3	5.5
MD1-3	0
MD1-2	15.2
MD1-1	2.1
MD2	14.0
MD1	17.1
M5	21.8
M4	12.1
MC	24.0
M3	7.1
MB	3.2
M2	4.4
MA	4.4
M1	11.1
TOTAL	$426.6

41. To provide further details, TABLE H-23 shows event damages with and without the recommended plan by flood probability. Notice that damages from floods which occur frequently (50, 20 and 10 percent floods) are entirely eliminated in all modified reaches and substantially reduced throughout the entire basin. Damages from intermediate frequency floods (4 and 2 percent floods) are reduced considerably. A flood event with a 0.2 percent probability is reduced in destructiveness by a moderate amount.

TABLE H-23
REMAINING EVENT DAMAGES ENTIRE BASIN
7-1/8% OCT 79 PRICE LEVELS

PROB	EVENT DAM -NO PLAN-	EVENT DAM -WITH 78.2-	PERCENT REMAINING
0.2%	$45,213,000	$33,145,000	73%
1.0	20,704,000	9,971,000	48
2.0	16,578,000	4,793,000	29
4.0	12,943,000	1,393,000	11
10.0	7,820,000	131,000	2
20.0	5,859,000	52,000	0.9
50.0	2,857,000	10,000	0.4

42. Average Annual Zonal Damages. TABLE H-24 provides data on average annual damages by zone. The zones investigated include the 10-year zone, 25-year zone, 50-year zone, 100-year zone, and SPF zone. The damages presented were evaluated by counting squares under the damage-probability curves and rounding. As a result, the data may in some cases appear slightly unusual. For the most part, however, these are good estimates.

43. Notice that 84 percent of all annual damages occur within the 10-year flood plain. This is due to the relatively flat topography of the 10-year event zone. Another 10 percent is added to damages as the zone expands to the 25-year event. Zonal damages show smaller incremental increases as the SPF zone is approached. This gradual incremental increase illustrates why greater level of protection than those achieved by the recommended plan are economically impossible.

TABLE H-24
AVERAGE ANNUAL DAMAGES BY ZONE
WITHOUT (WO) AND (W) THE RECOMMENDED PLAN
($1000)

ZONAL DAMAGES

Reach	0 10 W/O	W	0 25 W/O	W	0 50 W/O	W	0 100 W/O	W	0 SPF W/O	W
M16	114.2	0	123.2	0	124.8	2.2	126.6	3.4	131.0	13.3
M15	15.0	0	16.5	0.4	17.1	0.8	17.3	1.3	20.0	1.4
MH	34.7	0	34.7	0.3	34.8	0.5	34.8	0.9	35.0	5.1
M14	56.0	0	62.3	0	63.7	1.4	65.3	3.1	70.0	6.6
M13	82.1	0	85.4	0.8	86.9	1.4	87.6	1.8	94.0	7.7
M12	565.1	0	583.8	21.2	587.1	32.4	588.9	40.8	615.0	48.9
MG2	576.1	0	527.4	1.1	529.7	10.3	530.0	13.4	530.0	15.8
MG1	13.6	0	15.1	0.8	15.7	1.6	16.6	2.3	18.0	4.8
MF2	5.0	0.3	5.2	0.3	5.3	0.3	5.3	5.0	6.0	5.1
MF1	2.4	0.9	2.4	1.0	2.5	1.1	2.6	1.4	3.0	2.1
M11	289.8	C	301.5	0	307.0	10.2	309.9	20.5	314.0	56.9
M10	94.2	0	178.8	0.9	190.5	5.0	195.2	10.3	219.0	29.8
M9	55.4	0	68.4	1.2	73.9	5.6	77.0	11.0	99.0	15.7
M8	325.6	0	359.6	0.9	380.3	2.8	384.4	3.1	395.0	13.8
M7	2.2	0	2.9	0.05	3.5	0.8	4.4	1.6	7.0	4.1
M6	154.0	0	178.6	0.9	185.5	3.6	189.0	5.5	197.0	13.7
MD6	4.7	1.8	5.1	2.1	5.2	2.3	8.0	5.1	14.0	11.1
MD5	19.4	0	32.0	0.4	36.0	2.6	38.6	4.9	47.0	10.4
MD4	25.9	14.1	28.1	15.6	28.3	16.2	29.3	17.3	35.0	18.2
MD3	45.7	0	48.7	1.4	49.4	2.3	49.8	3.5	51.0	5.5
MD1-3	-	-	-	-	-	-	-	-	-	-
MD1-2	46.5	0	48.1	0	48.7	0.3	49.1	1.0	55.0	15.2
MD1-1	2.8	1.4	3.5	1.7	3.7	2.0	3.8	2.0	4.0	2.1
MD2	104.4	0	116.1	2.7	121.7	5.9	124.9	8.6	136.0	14.0
MD1	7.5	4.1	13.5	9.2	15.7	10.0	18.3	11.2	24.0	17.2

H-48

TABLE H-24
AVERAGE ANNUAL DAMAGES BY ZONE
WITHOUT (WO) AND (W) THE RECOMMENDED PLAN
($1000)

ZONAL DAMAGES

Reach	0 10 W/O	W	0 25 W/O	W	0 50 W/O	W	0 100 W/O	W	0 SPF W/O	W
M5	583.4	0	592.2	1.2	593.9	8.3	594.0	17.1	594.0	21.8
M4	51.2	0	60.7	0.2	63.1	3.4	64.5	6.5	68.0	12.1
MC	95.2	0	102.3	0.2	113.9	3.2	118.8	6.6	121.0	24.0
M3	48.9	0	54.8	1.5	58.1	3.2	58.6	5.2	67.0	7.1
MB	15.8	0	19.4	0.5	20.2	1.0	21.1	2.0	22.0	3.2
M2	19.3	0	23.6	0.8	24.5	1.7	24.8	2.6	26.0	4.4
MA	80.8	0	85.3	0	87.0	0	87.8	0	89.0	4.4
M1	13.3	0	24.6	0	32.0	0	34.3	1.1	39.0	11.1
	$3500.2	$22.6	$3802.8	$67.4	$3909.7	$142.1	$3960.6	$220.1	$4145.0	$426.6

44. Break-Even Interest Rate. Principles and Standards and ER 1105-2-351 require an analysis of the changes in benefits and costs with changes in the discount rate. TABLE H-25 provides this data. Figure H-4 presents the same information in graphical form. The break-even interest rate is about 10.25 percent. At this rate, the BCR equals 1.00.

45. TABLE H-25 shows annual cost (amortized Federal first cost) increasing with increases in the discount rate - as expected. Operation and Maintenance remains the same. Total annual costs rise, driven up by annualized Federal first costs.

46. Annual flood control benefits are interest free statistical parameters which are invariant to changes in the discount rate. As expected, flood control benefits do not increase or decrease. Recreation/environmental benefits are also interest free, evaluated by annual man-days and unaffected by changes in the discount rate.

TABLE H-25

BREAK-EVEN INTEREST RATE MALINE CREEK

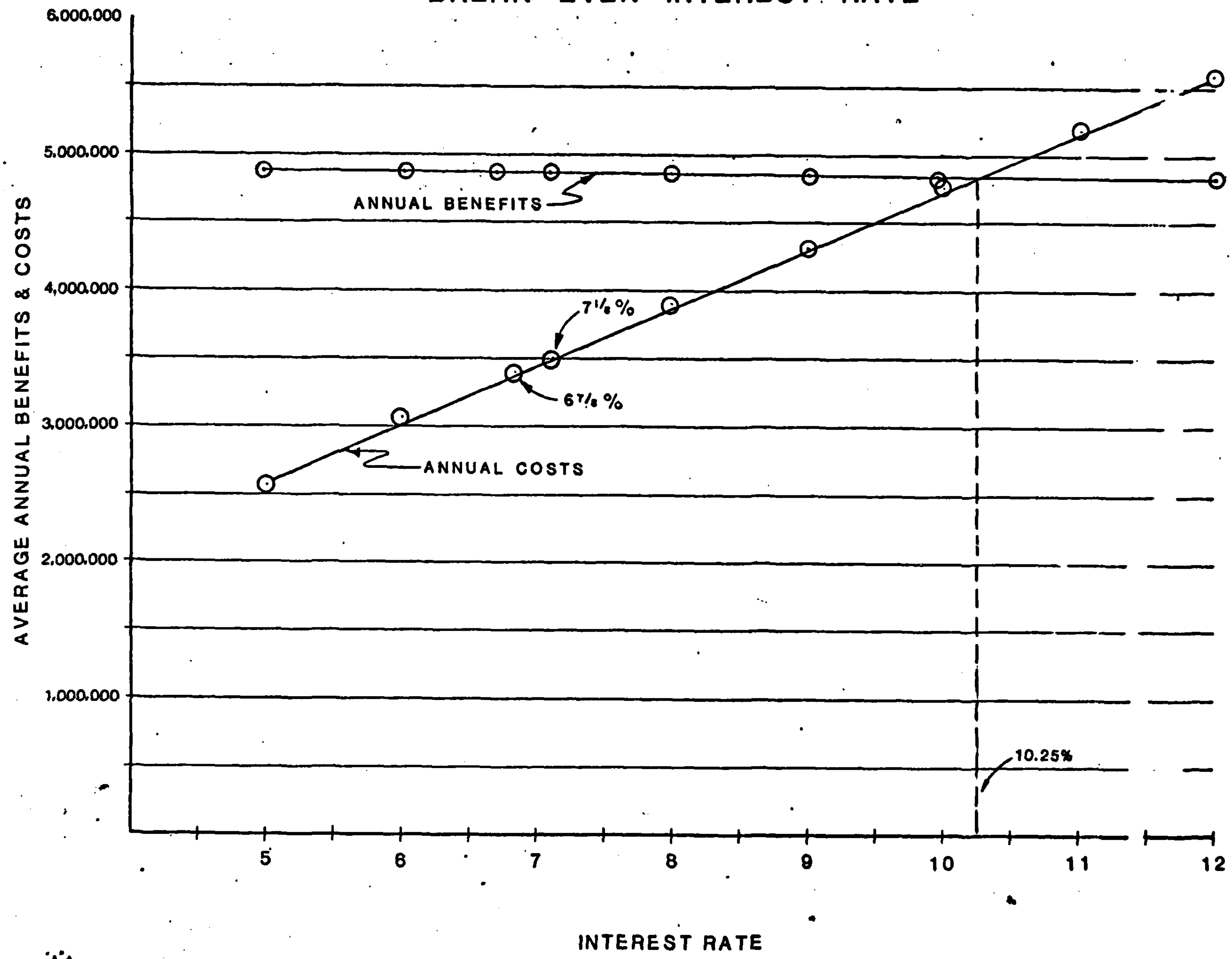
FEDERAL FIRST COST: $43,800,000 O&M: $450,000 100-YEAR LIFE OCT 79 PRICE LEVELS

Interest Rate	Partial Payment	Annual Cost	O&M	Total Annual Cost	Annual Benefits F.C.	Annual Benefits EQ/Rec	Annual Benefits Total	BCR
5	0.05038	$2,206,600	$ 450,000	$2,656,600	$3,718,400	$1,059,000	$4,777,400	1.80
6	0.06188	2,710,300	450,000	3,160,300	3,718,400	1,059,000	4,777,400	1.51
6-7/8	0.06883	3,014,800	450,000	3,464,800	3,718,400	1,059,000	4,777,400	1.38
7-1/8	0.07132	3,123,800	450,000	3,573,800	3,718,400	1,059,000	4,777,400	1.34
7-3/8	0.07381	3,232,900	450,000	3,682,900	3,718,400	1,059,000	4,777,400	1.30
8	0.08003	3,505,300	450,000	3,955,300	3,718,400	1,059,000	4,777,400	1.21
9	0.09002	3,942,900	450,000	4,392,900	3,718,400	1,059,000	4,777,400	1.09
10	0.10000	4,380,000	450,000	4,830,000	3,718,400	1,059,000	4,777,400	0.99
11	0.11000	4,818,000	450,000	5,268,000	3,178,400	1,059,000	4,777,400	0.91
12	0.12000	5,256,000	450,000	9,706,000	3,718,400	1,059,000	4,777,400	0.84

H-51

FIGURE H-4

BREAK EVEN INTEREST RATE



47. Because there is no anticipated urban growth in the Maline watershed, undiscounted benefits were not evaluated.

48. Discounted Annual Benefits. Discounted annual benefits are shown by each decade at two discount rates: 6-7/8 percent and 7-1/8 percent. TABLE H-27 below and Figure H-6 provides the data.

TABLE H-27
DISCOUNTED ANNUAL BENEFITS

Year	Discounted Benefits 6-7/8%	Discounted Benefits 7-1/8%
1989	2,480,100	2,538,400
1999	3,597,500	3,654,100
2009	4,127,500	4,214,600
2019	4,423,100	4,496,200
2029	4,575,200	4,637,700
2039	4,653,400	4,708,800
2049	4,693,600	4,744,500
2059	4,714,300	4,762,500
2069	4,725,000	4,771,500
2079	4,730,500	4,776,000

49. The data indicates that discounted annual benefits will catch up with annual cost by 1995 at 6-7/8 percent and at year 1994 at 7-1/8 percent. The payback period for the recommended plan is 16 years at 6-7/8 percent and 15 years at 7-1/8 percent.

MALINE CREEK, MISSOURI

SURVEY REPORT FOR FLOOD CONTROL
AND ALLIED PURPOSES

APPENDIX I

ENDANGERED SPECIES

APPENDIX I
ENDANGERED SPECIES

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MALINE CREEK, MISSOURI

ENDANGERED SPECIES

SUMMARY COMMENTS

Introduction

1. Concern regarding potential impacts to endangered species is a major plan formulation factor in all Corps' survey reports. This endangered species concern in the case of Maline Creek, Missouri, can best be demonstrated through the review of the "Endangered Species Assessment" document attached to this Appendix along with pertinent agency comments also reproduced herein.

2. The St. Louis District's letter of transmittal of the assessment document is on page I-3. The Fish and Wildlife Service's letter of response to the St. Louis District's assessment is printed on page I-2. The remainder of this appendix, beginning on Page I-4, is the assessment document transmitted to the Fish and Wildlife Service. This format has been used to allow the reviewer the option of reviewing the most pertinent correspondence. The coordination letters containing the St. Louis District's conclusions and the Fish and Wildlife Service's letter of concurrence provides a quick summary of the endangered species concern without the need to review the entire assessment.

Conclusions

3. In summary, the basic conclusion reached by the Maline Creek study team and verified through the other agency review process is that the Maline Creek recommended plan would result in no significant effect on endangered species.

M2-4

United States Department of the Interior
FISH AND WILDLIFE SERVICE

MAILING ADDRESS:
Post Office Box 25486
Denver Federal Center
Denver, Colorado 80225

STREET LOCATION:
134 Union Blvd.
Lakewood, Colorado 80228

IN REPLY REFER TO:
FA/SE/COE--Maline Creek,
Missouri (6-3-80-I-3)

[illegible] 1979

Mr. Jack R. Niemi
Engineer in Charge
U.S. Army Corps of Engineers
210 North 12th Street
St. Louis, Missouri 63101

Dear Mr. Niemi:

This is in regard to your letter of September 26, 1979, concerning your biological assessment on Maline Creek, Missouri.

We concur with your biological assessment that there will be no impact on the bald eagle, American peregrine falcon, and the proposed plant, Mead's milkweed.

This completes the Section 7 consultation procedure. Should the project change significantly, consultation should be reinitiated. We appreciate your cooperation in protecting endangered species.

Sincerely yours,

Danny M. Regan

Acting Regional Director

Mr. Harvey Willoughby
Regional Director
U. S. Fish and Wildlife Service
P. O. Box 25486
Denver Federal Center
Denver, Colorado 80225

Dear Mr. Willoughby:

Reference your letter, FA/SE/COE-Maline Creek, Missouri, dated 4 April 1979, requiring a biological assessment on endangered species that may be present in the project area. The assessment is inclosed (Inclosure 1).

In essence, the conclusion from this assessment is that the Maline Creek project would result in no significant effect on endangered species.

I do not believe any formal consultation is necessary on this project, and we will proceed under that assumption unless you choose to request consultation.

Sincerely,

SIGNED

1 Incl
As stated

JACK R. NIEMI
Engineer in Charge

Copy furnished: (w/incl)
Mr. Tom A. Saunders,
Area Manager
U. S. Fish & Wildlife Service

Mr. Larry R. Gale, Director
Missouri Department of Conservation

WATER RESOURCE INVESTIGATION

ST. LOUIS METROPOLITAN AREA, MISSOURI AND ILLINOIS

MALINE CREEK, MISSOURI

ENDANGERED SPECIES ASSESSMENT

U.S. ARMY ENGINEER DISTRICT
ST. LOUIS, MISSOURI
JUNE 1979

APPENDIX I
I-4

PROJECT DESCRIPTION AND HISTORY

INTRODUCTION

1. The Maline Creek watershed covers 16,170 intensely urbanized acres (25 square miles). This area includes a small part of the city of St. Louis, portions of unincorporated St. Louis County, and all or parts of 23 municipalities within north St. Louis County (PLATE 1). The primary purpose of this study has been to investigate the flooding and allied water resource problems and needs of the Maline Creek watershed.

AUTHORIZATION AND HISTORY

2. The authority for this preauthorization study stems from the St. Louis District, Corps of Engineers' comprehensive regional study entitled, "St. Louis Metropolitan Area, Missouri and Illinois, Study" (Metro Study). Because the Maline Creek report is an interim report, it represents only a partial response to the six resolutions pertaining to the Metro Study adopted by the Committees on Public Works of both the U.S. Senate and U.S. House of Representatives. These resolutions in chronological order are: 7 Apr 66 (Senate): 4 Oct 66 (Senate); 15 Jul 70 (Senate); 29 Jul 71 (House of Representatives); 2 Oct 72 (Senate); and 12 Oct 72 (House of Representatives).

CONSTRUCTION SCHEDULE

3. This is a preauthorization (Survey Report) study. It must be approved by Congress before detailed planning can begin. At the present time, 1990 is projected as the beginning year of construction.

SURVEY REPORT DOCUMENTS

4. In the interest of clarity of presentation and reference, the Survey Report will be arranged into a main report (Volume One) and appendices (Volume Two).

5. The main report will be a non-technical presentation of the study. It will also contain the recommendations. A draft main report, entitled Maline Creek, Missouri, Survey Report, Volume One, Summary and Recommendations, was prepared in March 1978. It will be revised to show current planning efforts before it is circulated for general review.

6. Volume Two will contain the appendices. It is a technical report providing the detailed inventory and engineering data required for development of a selected plan. It is the key document for the technical reviewer. Appendix II will contain all pertinent correspondence. A draft Volume Two, Appendices and a draft Environmental Statement were prepared in March 1978. These will be revised to reflect current planning and to comply with current guidelines for report preparations. In accordance with CEQ Regulations of November 1978, the Environmental Statement will now be included as part of the Main Report.

SELECTED PLAN FEATURES

7. The recommended plan includes the following structural and nonstructural features (PLATES 2 and 3).

Detention Reservoir Sites

a. Eight dry flood control detention basins (104 total acres).

b. Purchase of an additional 280 acres to be preserved as wildlife habitat (at pond sites) or for recreational development.

c. Five fish ponds ranging in size from 2 to 4 acres.

Stream Corridor

a. Purchase of the 10-year floodplain (474 acres) in the entire mainstem of Maline Creek, plus short segments of some of the tributaries.

b. 3.29 miles of earth channel improvements.

c. 5.05 miles of concrete floodwall (3 feet high) to protect structures located immediately adjacent to the creek.

d. 3.31 miles of earth levee (3 feet high) to protect structures located farther from the creek, but still subject to the 10-year flood.

e. 212 small interior catch basins.

f. Sixteen sewer modifications.

g. Five bridge replacements.

h. Two bridge improvements.

i. 1.67 miles of streambank stabilization (riprap or gabion).

j. 77 acres of selective clearing (brush hogging for flood passage).

k. Eighteen aquatic habitat structures (riffle areas) to improve the creek as fish habitat.

l. 10 miles of nature/recreation trails.

m. No selective clearing in good-to-excellent quality wildlife habitat located in Bellefontaine County Park on the mainstem and in a small 4-acre bottomland hardwood forest along Tributary MD1-1.

ENVIRONMENTAL SETTING WITHOUT THE PROJECT

PHYSICAL ELEMENTS

Geology, Soils, and Natural Resources

8. The topography of the watershed is predominately characterized by gently sloping surfaces. The local relief is less than 300 feet. The mean slope of the longest portion of Maline Creek is approximately 1 foot of vertical drop in 220 feet.

9. The principal soil material over bedrock is a wind deposited loess which is frequently clay rich, particulary at extreme depths. In the uplands, the loess-derived soils consist primarily of silt loams, while the soils associated with the main channel consist of silts, clays, or combinations extending deep to bedrock. Bedrock, where identified, is usually shale and is located well below the creek bottom, varying from a depth of 5 to 10 feet near the headwaters to 25 feet or more along the main channel.

10. Limestone and shale are the notable mineral resources having economic significance. These commodities are quarried for use in cement production.

Drainage

11. The principal surface drainage system is 36.2 miles long and consists of 10.6 miles of Maline Creek main channel and ten major tributaries with lengths varying from 1.4 to 4.2 miles. In general, Maline Creek flows in a southeasterly direction, emptying into the Mississippi River at river mile 187.2, approximately 8 miles downstream from the confluence of the Mississippi and Missouri Rivers. Headwater channels are predominately storm sewers, some of which are concrete lined and some inclosed in culverts, which flow into open channels reaching a maximum size of 25-foot depth and 100-foot width near the south.

Water Quality

12. Water quality in Maline Creek and its major tributaries ranges from fair to poor, depending upon the sampling site and time of sampling. Excessive measurements of pH, dissolved oxygen, nutrients, chloride, and heavy metals were made during studies conducted for this report.

Weather and Climate

13. The study area has four distinct seasons, normally without prolonged periods of extreme cold, extreme heat, or high humidity. The average yearly temperature is 55°F. During the winter, the average minimum temperature is 15°F, while during the summer, the average maximum temperature is 90°F. The average annual amount of precipitation, as recorded at Lambert-St. Louis International Airport, is 35.4 inches.

Air Quality

14. The Maline Creek watershed is generally in compliance with federal air quality standards. Despite occasionally high incidences of fugitive dust, and high levels of oxidants and carbon monoxide from transportation related sources, the St. Louis County Department of Community Health rates this watershed as one of the cleanest in the St. Louis metropolitan area.

CULTURAL ELEMENTS

Population Characteristics

15. At the time of the 1970 Census, the population of the Maline Creek watershed was 125,330, which represents a 20 percent increase from 1960.

Land Use

16. Land use is predominately residential. Of the total 16,170 acres, more than 62 percent fell into this category as of 1975. More specifically, the major land use categories and their respective total acreages as of 1975 are as follows: residential, 10,141 (62.7 percent); commercial-industrial, 1,146 (7.1 percent); public-recreation, 2,062 (12.8 percent); and agriculture-vacant, 2,821 (17.4 percent).

Noise

17. Due to watershed's location within a highly urbanized area, it is affected by several noise pollution sources. Most notable is the noise emanating from highways and air traffic.

Aquatic Ecosystem

18. Lentic habitat within the Maline Creek watershed consists of several small ponds, ranging in size from 1 to 6 surface acres. Some of the ponds have viable fish populations.

19. Lotic habitat consists of Maline Creek and its tributaries. Poor water quality and a lack of habitat diversity limit the variety of aquatic organisms that occur in the creek to pollution-tolerant forms. With one exception, the fish community in stream reaches consists almost entirely of fathead minnows. The one exception is a site near the mouth of Maline Creek, where 15 species of fish have been collected in spite of poor water quality found at that site.

Terrestrial Ecosystem

20. Most of the natural vegetation in the watershed has been replaced by urbanization. That which remains is mostly forest cover concentrated in the northern portion of the watershed on steep slopes and along stream courses. The largest amount of vegetative cover is mixed suburban, covering 77 percent of the watershed. This cover varies in wildlife habitat value from the low-valued monoculture of manicured lawns to a high-value, diverse interspersion of trees, grass, and shrubs.

Endangered and Threatened Species

21. In a letter, LMSED-BA, dated 13 March 1979 (Inclosure 1), the St. Louis District requested the U.S. Fish and Wildlife Service,

Denver Regional Office, to provide a list of endangered or threatened species that may occur in the study area. In a letter, FA/SE/COE - Maline Creek, Missouri, dated 4 April 1979 (Inclosure 2), the Fish and Wildlife Service noted three species that may be present and for which a biological assessment must be prepared. Two of the species are currently listed as endangered, the bald eagle (Haliaeetus leucocephalus) and American peregrine falcon (Falco peregrinus anatum), and one is proposed, the Mead's milkweed (Asclepias meadii).

22. Several sources were consulted to determine if these species occur in the study area. Mr. John Brady, Wildlife Biologist with the St. Louis District, did the wildlife inventory in the study area. In the draft Maline Creek Survey Report, Volume 2, pages B-58 and B-59, he concluded that, during migration, the bald eagle or peregrine falcon may occasionally be found in the study area. However, because of the intensive urban development in the area, no important habitat is found in the study area, and the possibility of such occurences would be remote.

23. Frank Kulfinski, Botany Professor of Southern Illinois University-Edwardsville, did an inventory of the vegetation in the study area. His conclusions are also reported in the draft Survey Report, page B-58. He could not identify some species, because of the lack of flowering material at the time he was in the field. Nevertheless, he believed it unlikely that any were endangered or threatened species.

24. In 1977, Robert Mohlenbrock, Botany Professor at Southern Illinois University - Carbondale, prepared a report, entitled Inventory of Endangered Plants, St. Louis District. In his

discussion of the Mead's milkweed, he pointed out that only two collections of this species have been made in the St. Louis District, one in 1833 and one 1898. He could not relocate the species during his field work, and concluded that this species is extinct in the St. Louis District.

25. In a letter, LMSED-BA, dated 5 May 1979 (Inclosure 3), Edgar Denison, author of Missouri Wildflowers, was asked about the possibility of the Mead's milkweed occurring in the study area. His response, dated 16 May 1979 (Inclosure 4), was that it is unthinkable that this species could be found in the study area.

26. In a letter, LMSED-BA, dated 7 May 1979 (Inclosure 5), the Missouri Department of Conservation was asked about the possibility of the bald eagle, American peregrine falcon, or Mead's milkweed occurring in the Maline Creek watershed. Their letter of response, dated 18 June 1979 (Inclosure 6), concluded that it is doubtful that either the bald eagle of peregrine falcon use the Maline Creek area to any extent. They also concurred with the other mentioned sources that the Mead's milkweed is probably extinct in the area.

FUTURE ENVIRONMENTAL SETTING WITHOUT THE PROJECT

Physical Elements

27. The physical elements in the Maline Creek watershed, including the geology, soils, and natural resources, climate and weather, and air quality, are expected to remain relatively unchanged in the future without the proposed project. Streambank erosion is expected to continue, resulting in stream siltation, property damages, and a blighting influence on esthetic values. Drainage is expected to remain essentially as is, with no major flood control improvements likely to be installed.

28. Water quality in the watershed is expected to improve during the next decade, because of the Environmental Protection Agency's planned implementation and enforcement of existing and future water pollution control standards.

Cultural Elements

29. The OBERS Series E, 1972 population projection, adapted from OBERS area 194, St. Louis, Missouri-Illinois, for the Maline Creek watershed, is 168,000 for the year 2020.

30. Future land use for the without project condition (2020) is based upon St. Louis County's "General Plan." The major land uses and their respective projected acreages for 2020 are as follows: residential, 11, 070 (68.4 percent); commercial-industrial, 1,900 (11.8 percent); institutional-recreation, 2,460 (15.2 percent); and agriculture-vacant, 740 (4.6 percent).

31. Noise pollution is expected to increase significantly because of increased urbanization and the increase in air traffic due to the expansion of Lambert-St. Louis International Airport.

Biological Elements

32. No change in the aquatic habitat is expected. However, there may be an increase in species diversity due to the projected improvement in water quality.

33. Undeveloped wildlife habitats are expected to decrease, due to urban developmental pressures, until the only remaining undeveloped habitat will be on public land and in the floodplain immediately

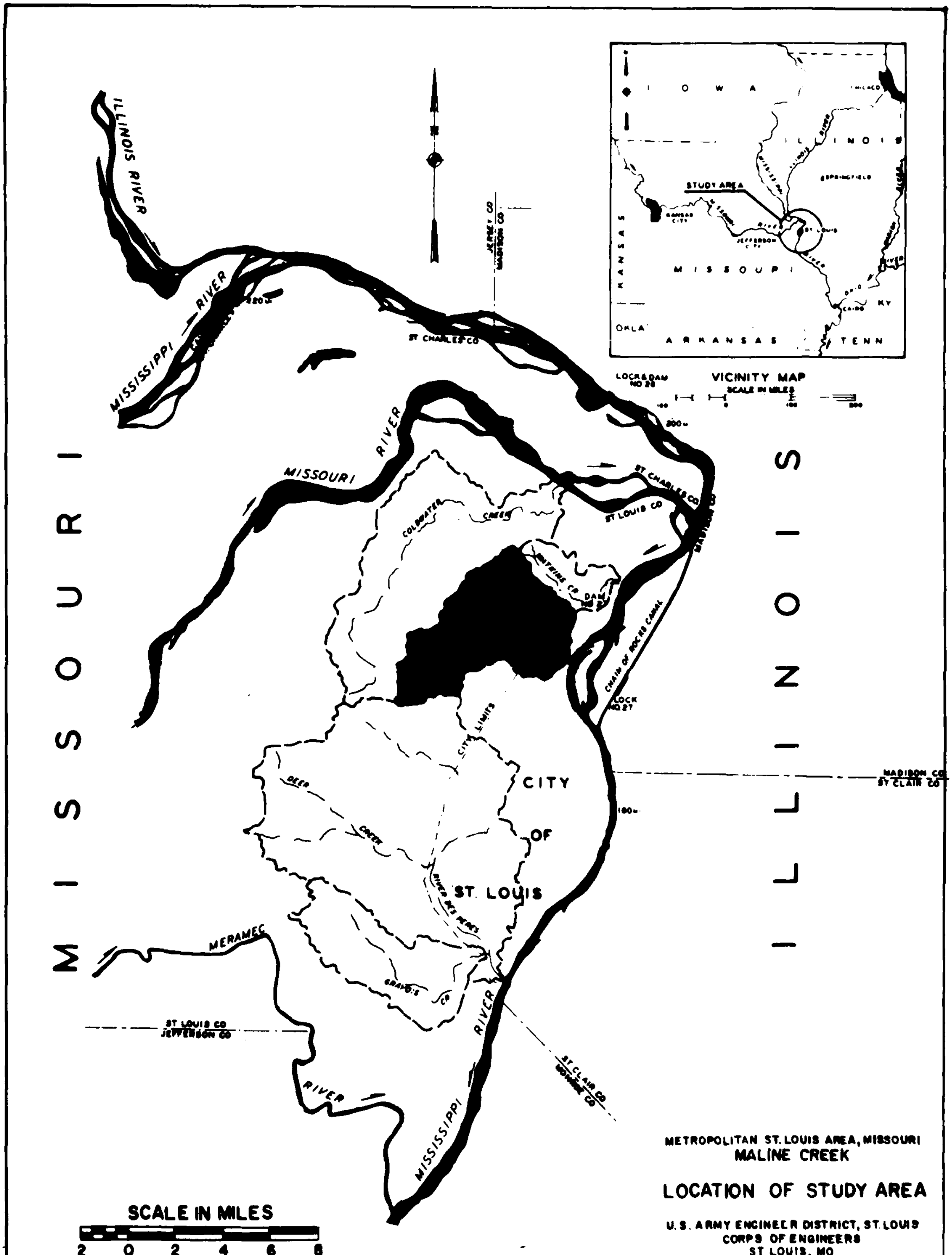
adjacent to the creek. The decrease in habitat would cause a decrease in diversity and abundance of wildlife species. Residential suburban areas are expected to continue to provide habitat.

PROBABLE IMPACT OF THE PROPOSED ACTION ON ENDANGERED SPECIES

34. Virtually all sources consulted concluded that the Mead's milkweed is extinct in the Maline Creek watershed. Therefore, no project induced impact on this species is expected.

35. The sources consulted in regard to the bald eagle and the American peregrine falcon were doubtful that the Maline Creek watershed is inhabited to any extent by these species, although a remote possibility exists that the area could be used briefly during migration.

36. This project would be beneficial to the bald eagle or peregrine falcon if any should ever be found in the area. As mentioned in paragraph 7, essentially all of the 10-year floodplain will be purchased in fee. Approximately 91 acres of this land will be cleared for construction of flood protection structures, fish ponds, and outdoor recreation developments. However, the total project acreage purchased will be 858 acres, 567 of which are currently undeveloped wildlife habitat. Under the projected urban development, with no project, 326 of those acres would be cleared, leaving a net 241 acres of undeveloped wildlife habitat. With the selected plan, 476 acres of undeveloped lands would remain, and local assurances would be obtained to maintain most of this acreage in its "natural" state.

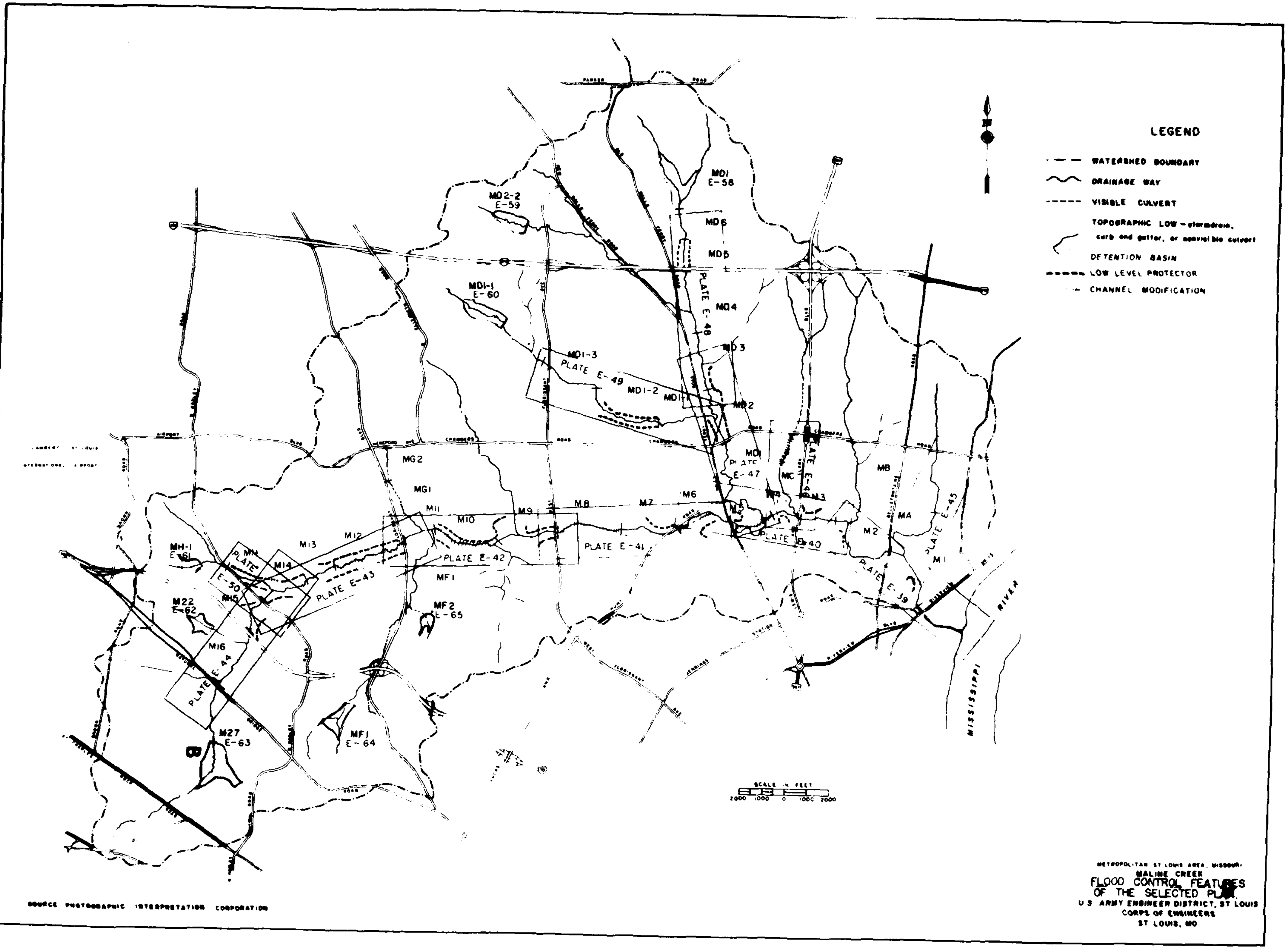


METROPOLITAN ST. LOUIS AREA, MISSOURI
MALINE CREEK

LOCATION OF STUDY AREA

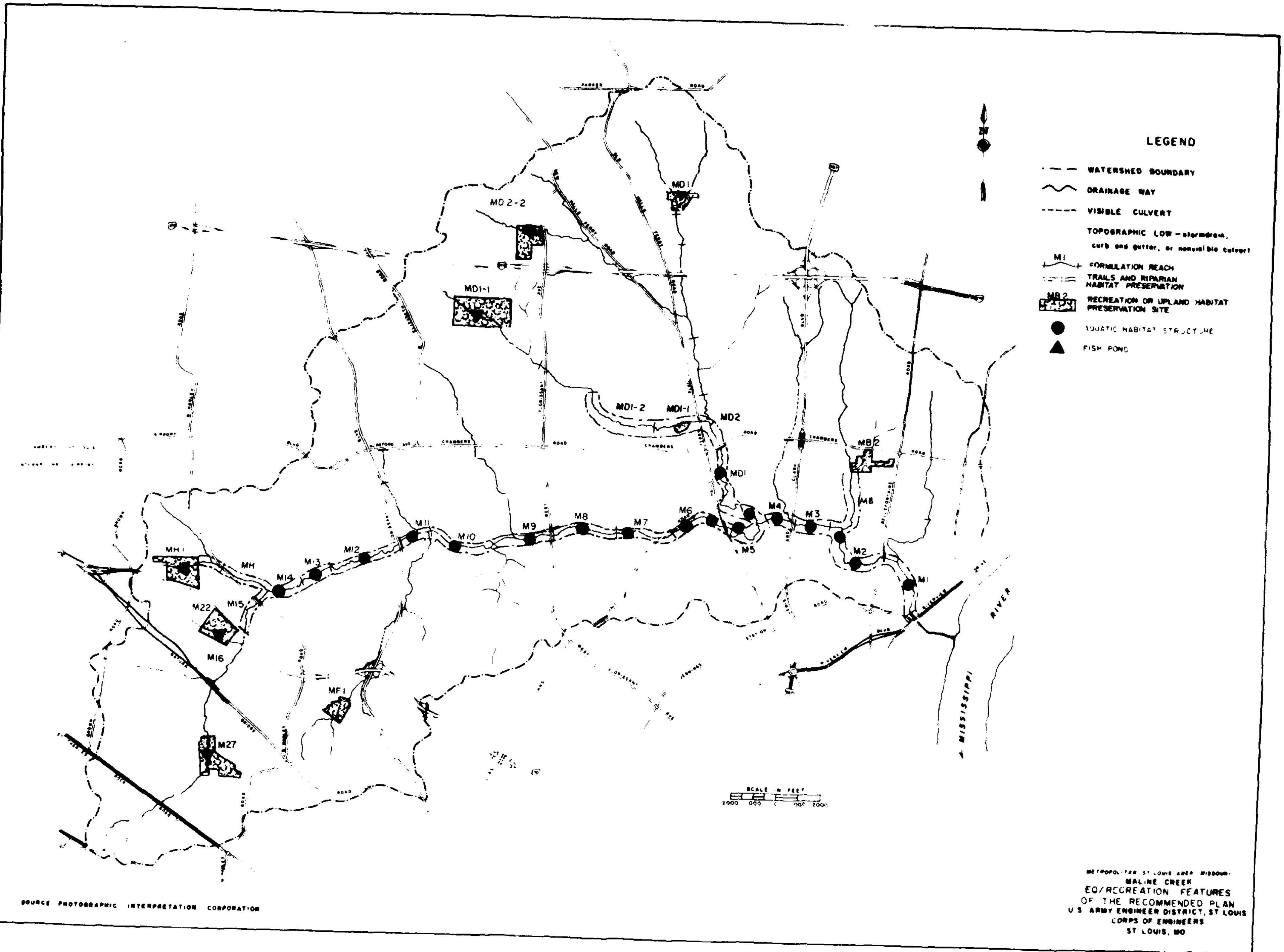
U.S. ARMY ENGINEER DISTRICT, ST. LOUIS
CORPS OF ENGINEERS
ST LOUIS, MO.

PLATE 1



LEGEND
WATERSHED BOUNDARY
DRAINAGE WAY
VISIBLE CULVERT
TOPOGRAPHIC LOW - stormdrain, curb and gutter, or nonvisible culvert
DETENTION BASIN
LOW LEVEL PROTECTOR
CHANNEL MODIFICATION
MD1 E-58
MD2-2 E-59
MD6
MD5
MD1-1 E-60
PLATE E-48
MD4
MD3
MD1-3
PLATE E-49
MD1-2
MD1
MD2
MD1 PLATE E-47
MC
PLATE E-46
M3
M4
M8
MA
M2
PLATE E-45
M1
PLATE E-40
PLATE E-39
MG2
MG1
M11
M10
M9
M8
M7
M6
M5
PLATE E-41
PLATE E-42
M12
M13
PLATE E-43
MF1
MF2 E-65
MH-1 E-61
PLATE E-50
M14
M15
M22 E-62
M16
PLATE E-44
M27 E-63
B
MF1 E-64
MISSISSIPPI RIVER
PARKER ROAD
CHAMBERS ROAD
AIRPORT
LAMBERT ST. LOUIS INTERNATIONAL AIRPORT
WEST FLORISSANT
SCALE IN FEET
2000 1000 0 1000 2000
SOURCE PHOTOGRAPHIC INTERPRETATION CORPORATION
METROPOLITAN ST LOUIS AREA, MISSOURI
MALINE CREEK
FLOOD CONTROL FEATURES
OF THE SELECTED PLAN
U.S. ARMY ENGINEER DISTRICT, ST LOUIS
CORPS OF ENGINEERS
ST LOUIS, MO

PLATE 2



LEGEND
WATERSHED BOUNDARY
DRAINAGE WAY
VISIBLE CULVERT
TOPOGRAPHIC LOW – stormdrain, curb and gutter, or nonvisible culvert
M1
FORMULATION REACH
TRAILS AND RIPARIAN HABITAT PRESERVATION
MB2
RECREATION OR UPLAND HABITAT PRESERVATION SITE
AQUATIC HABITAT STRUCTURE
FISH POND
MD1
MD2-2
MD1-1
MD1-2
MD2
MB2
M1
M2
M3
M4
M5
M6
M7
M8
M9
M10
M11
M12
M13
M14
M15
M16
MH
MH1
M22
M27
MF1
MISSISSIPPI RIVER
SCALE IN FEET
SOURCE PHOTOGRAPHIC INTERPRETATION CORPORATION
METROPOLITAN ST LOUIS AREA MISSOURI
MALINE CREEK
EQ/RECREATION FEATURES
OF THE RECOMMENDED PLAN
U.S. ARMY ENGINEER DISTRICT, ST LOUIS
CORPS OF ENGINEERS
ST LOUIS, MO

PLATE 3

112-4-2

LMSED-BA

13 March 1979

Mr. Harvey Willoughby
Regional Director
U.S. Fish and Wildlife Service
P.O. Box 25486
Denver Federal Center
Denver, Colorado 80225

Dear Mr. Willoughby:

Reference is made to your letter, FA/SE-Coop.-Federal, dated FEB 21 1979, to Colonel McKinney, providing interim guidance on Endangered Species Act consultation procedures for construction projects.

The St. Louis District is in the process of preparing a Survey Report for our Maline Creek, Missouri, Water Resources Investigation. In March 1978, we prepared a draft Summary and Recommendations Report and a draft Environmental Statement and submitted these to our Division office for in-house review. We are now making revisions to these documents and will be distributing them for external review in mid-1979.

During the course of this investigation, an inventory and assessment was made of the biological resources in the study area. The aquatic resources and the vegetation were inventoried by outside consultants. St. Louis District biologists did the terrestrial wildlife inventory and made an overall qualitative evaluation of the study area's biological resources and an assessment of potential impacts of the project.

The St. Louis District's assessment came to the following conclusions: The Maline Creek watershed contains no important habitat for Federally-classified threatened or endangered species. No Federally-classified threatened or endangered plants occur in the watershed. Some animals of Federally-unique classification, especially migratory bird species, may occasionally be found in the watershed.

Inclosure 1

RAGLAND/ED-W/2946/407

LMSED-BA 13 March 1979

Mr. Harvey Willoughby

Because our effort was completed prior to receipt of your interim guidelines, we are ahead of those steps outlined in the flow chart attached to your 21 February letter. We have, in fact, completed an assessment of potential impacts on endangered species prior to consulting with you on the necessity of this assessment for particular species. Consequently, this letter has a dual purpose. The first purpose is to advise you that we have conducted a biological assessment of the project area and that we do not believe there are any listed or proposed threatened or endangered species in the area. Secondly, I request any information that you may have on species not considered in our assessment.

I believe that this assessment satisfies the requirements of Section 7(c) of the Endangered Species Act Amendments of 1978 and that no further consultation is necessary for this project. Please let me know if you concur, or if you believe that additional studies or consultation are necessary.

The following documents are being sent under separate cover to demonstrate how we arrived at our conclusions and to assist you in your deliberations. If you need further documentation or assistance, please contact Mr. Dan Ragland of our Environmental Studies Section, at telephone (314) 268-2946.

Maline Creek, Missouri, Survey Report, Vol. 1, Summary and Recommendations (March 1978, Draft) (Incl 1).

Maline Creek, Missouri, Survey Report, Vol. 2, Appendices, pp. B1 to B75 (March 1978, Draft) (Incl 2).

Maline Creek, Missouri, Survey Report, Draft Environmental Statement (March 1978) (Incl 3).

ED-RAGLA

ED-BU

ED-RAHUB

ED RASMUSS

Sincerely yours,

3 Incl
As stated

JACK F. RASMUSSEN
Chief, Planning Branch

CF: ED-B
ED-BU

M2-4-

United States Department of the Interior

FISH AND WILDLIFE SERVICE

MAILING ADDRESS
Post Office Box 25486
Denver Federal Center
Denver, Colorado 80225

STREET LOCATION:
[illegible] uon Blvd
Lakewood, Colorado 80228

IN REPLY REFER TO:
FA/SE/COE--Maline
Creek, Missouri

APR - 4 1979

Mr. Jack F. Rasmussen
Chief, Planning Branch
Corps of Engineers
210 North 12th Street
St. Louis, Missouri 63101

Dear Mr. Rasmussen:

This responds to your letter of March 13, 1979, in regard to your proposed Maline Creek project.

In accordance with Section 7(c) of the Endangered Species Act Amendments, we have reviewed your information and determined that the following listed and proposed endangered species may be present in the project area.

<u>Listed Species</u>:

Bald eagle (<u>Haliaeetus leucocephalus</u>)
American peregrine falcon (<u>Falco peregrinus anatum</u>)

<u>Proposed Species</u>:

Mead's Milkweed (<u>Asclepias meadii</u>)

Section 7(c) of the Act Amendments requires that you prepare a biological assessment to determine if the proposed project will affect the above species.

Thank you for your interest and cooperation in conserving endangered species. If we can be of further assistance, please contact us.

Sincerely yours,

Harvey Willoughby

HARVEY WILLOUGHBY
Regional Director

CONSERVE AMERICA'S ENERGY

Save Energy and You Serve America!

<u>Inclosure 2</u>

BRADY/ED-W/5711/529

LMSED-BA

5 May 1979

Mr. Edgar Denison
5[illegible] East Adam Street
[illegible]rkwood, Missouri 63122

Dear Mr. Denison:

Reference is made to a telephone call between yourself and John Brady, Wildlife Biologist, of my staff, on 3 May 1979, concerning the possibility of Mead's milkweed (Asclepias meadii Torr.) occurring in the Maline Creek study area. We are inclosing a map which shows the locaton of the area and we would appreciate your comments on the possible existence of this plant in the Maline Creek study area. In addition, I am inclosing for your use, the following documents:

a. Inventory of Endangered Plants, St. Louis District and

b. An Inventory of Rare and Endangered Plant Species Found in the St. Louis, Missouri, Corps of Engineers District.

Both of these documents were prepared by Dr. Robert Mohlenbrock.

Thank you for your time and trouble.

Sincerely,

3 Incl
As stated

JACK F. RASMUSSEN
Chief, Planning Branch

ED-F
RAHUBK

ED
RASMUSSE

Inclosure 3

May 16, 1979

Mr. Jack F. Rasmussen
Chief, Planning Br[illegible]ch
Corps of Engeneers, St.Louis District
210 North 12th street
St.Louis, Mo. 63101

Dear Mr. Rasmussen:

Thank you for your letter of May 5 and the interesting material concerning rare and endangered plants, which you mailed to me.

Asclepias meadii While found on glades, the plant is primarly a dweller of prairies and western ones at that. As prairie has been destroyed in the Maline Creek area, it seems unthinkable, that this species could be found there. A.m. seems to have problems of reproduction, possibly a lack of a specific insect to affect pollination, as it produces only a few seeds per infloresecnse. Thus, even if a plant was brought in, it would have a hard time to survive.

I was impressed by the report prepared by the Biotic Consultants, Inc. and offer a few minor comments.

Plantago cordata is so common that the group of botanically interested people does not believe it should be considered rare nor endangered. Almost any creek in eastern Missouri has a population (Danville Wildlife area, St.Francois State Park,and dozens more.).

Boltonia decurrens Magnificent specimens in large quantities to over 2 m tall in mud bottoms around large lakes just east of Granite City Steel Plant. The land is - as far as I know - owned by Mr. William F. Nichols, 498 Layton Road, East St. Louis, Ill. 62201 Tel 618-876-2225.

Sincerely Yours

Edgar Denison

Inclosure 4

EDGAR DENISON
544 EAST ADAMS
ST. LOUIS, MO. 63122

M2-4-29

LMSED-BA

7 May 1979

Mr. Larry R. Gale, Director
Missouri Department of Conservation
P.O. Box 180
Jefferson City, Missouri 65102

Dear Mr. Gale:

Reference my letter, LMSED-BA, dated 13 March 1979, to Mr. Harvey Willoughby, inquiring as to the need for a biological assessment on endangered species that may be present in the St. Louis District's Maline Creek study area (Inclosure 1). Also, reference his response, FA/SE/COE - Maline Creek, Missouri, dated 4 April 1979 (Inclosure 2).

The Fish and Wildlife Service advised the St. Louis District that a biological assessment must be performed to determine the potential impacts of our Maline Creek project on the bald eagle, American peregrine falcon, and Mead's milkweed. I would like the assistance of your natural history biologists in doing an assessment on those species.

In a letter, FA/SE - Coop-Federal, dated 21 February 1979, Mr. Willoughby outlined six components of a biological opinion (Inclosure 3). My staff can assemble all or portions of all of those components. However, I am hopeful that your staff can provide some assistance with item number 4, the biological data.

The basic questions that I pose for your biologists is this:

> Is it likely that any of these three species occur in the Maline Creek watershed? If so, what is the seasonal distribution and relative abundance of each species?

Mr. Edgar Denison has been contacted regarding the Mead's milkweed, and has given his opinion that this species does not occur in the watershed. Nevertheless, if you have information contradictory to that, we want your data. No contacts other than this one with your agency have been made in regard to the bald eagle or peregrine falcon.

Inclosure 5

RAGLAND/ED-W/5711/53

LMSED-BA 7 May 1979

Mr. Larry R. Gale, Director

We have done a biological inventory in the study area. We also have on file, a report by Dr. Robert Mohlenbrock entitled, Inventory of Endangered Plants, St. Louis District, that includes a discussion of the Mead's milkweed. If your biologists would like to have those data for your deliberations, we will provide copies. Likewise, if you feel that a joint field trip would be of benefit, my staff is available for this purpose.

If you have any questions about this request, please contact Mr. Dan Ragland of my Environmental Studies Section at telephone number 314/263-5711.

Sincerely,

JACK F. RASMUSSEN
Chief, Planning Branch

3 Incl
As stated

CF: ED-B
ED-BU

ED-
RAGLA

DL

ED-
RAHUE

ED
RASMUSS

MISSOURI DEPARTMENT OF CONSERVATION

MAILING ADDRESS:
P.O. Box 180
Jefferson City, Missouri 65102

STREET LOCATION:
2901 North Ten Mile Drive
Jefferson City, Missouri 65101

Telephone 314/751-4115
LARRY R. GALE, Director

June 18, 1979

Mr. Jack F. Rasmussen
Chief, Planning Branch
U. S. Army Engineer District
St. Louis Corps of Engineers
210 North 12th Street
St. Louis, Missouri 63101

Re: LMSED-BA

Dear Mr. Rasmussen:

Thank you for the opportunity to provide input into the status of endangered species that may occur in the Maline Creek study area. Members of the Department staff have evaluated the status of the bald eagle, peregrine falcon and Mead's milkweed. The following information is provided for your use.

Missouri leads the Missouri Flyway in the number of bald eagles, as determined by the U. S. Fish and Wildlife Service Mid-Winter Eagle Inventory. Last January, 810 individuals were counted in the state. This was 1/3 of the total counted in the 12 Mississippi Flyway states. D. A. Spencer (Wintering Bald Eagle, 1976. National Agricultural Chemicals Association, Washington, D.C.) has estimated that 1,000 bald eagles winter or migrate through Missouri each year. Eagles have not been known to nest successfully in Missouri since the early 1900's; however, recent nestings in southern Illinois make future nestings in Missouri seem more possible. Bald eagles tend to feed near large bodies of water, but may use a secluded night roost up to 20 miles away from the feeding site. These roosts are often located in hilly areas that offer updraft for soaring.

To our knowledge, the peregrine falcon has never been reported to breed in Missouri; the subspecies anatum probably did breed here in presettlement times, just as it did in other nearby states. Peregrines migrate through Missouri. Between one and 10 individuals are reported each spring and fall, and an occasional individual is reported in winter. It is likely that a far larger number of peregrines migrate through the state and are never

Inclosure 6

Missouri Department Of Conservation

reported. Due to the extent of development in the Maline Creek Watershed, we doubt that the area is utilized to any extent by bald eagles or peregrine falcons.

We have studied the status of Mead's milkweed, Asclepias meadii and are generally in agreement with the reports of Mr. Edgar Denison and Dr. Robert Mohlenbrock that indicate Mead's milkweed is probably no longer present in the watershed.

If you have further questions, please call.

Sincerely,

Larry R. Gale
LARRY R. GALE
DIRECTOR

cc: U. S. Fish and Wildlife Service
Kansas City, Missouri

MALINE CREEK, MISSOURI

SURVEY REPORT FOR FLOOD CONTROL
AND ALLIED PURPOSES

APPENDIX J

PRELIMINARY ASSESSMENT

CLEAN WATER ACT (SECTION 404)

APPENDIX J

CLEAN WATER ACT
(SECTION 404)

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MALINE CREEK, MISSOURI

CLEAN WATER ACT (SECTION 404)

INTRODUCTION

1. Section 404 of the Clean Water Act established a permit program for the purpose of regulating discharges of dredged or fill material into waters of the United States. Under Section 404(b), proposed discharges of dredged or fill material must conform to guidelines developed by the Administrator, Environmental Protection Agency.

2. On 5 September 1975, in accordance with Section 404(b), the Environmental Protection Agency published regulations (40 CFR 230) which outline criteria and procedures for evaluating activities subject to Section 404. The Environmental Protection Agency regulation provided for protection of navigable waters of the United States and tributaries of navigable waters, upstream to the headwaters of these streams and landward to ordinary high water. These regulations also provided for protection of adjacent wetlands.

3. On 19 July 1977, the Corps of Engineers published regulations (33 CFR 323) that redefined and broadened the Section 404 authority to affect "waters of the United States." These regulations included authority to regulate discharges of dredged or fill material into streams, including intermittent streams, that are not navigable waters or tributaries of navigable waters. This authority extends up to and including headwater reaches of these streams, and extends landward to ordinary high water. Nationwide permit authority was granted for discharges into headwater reaches of streams, provided that conditions to preserve environmental quality, published in 33 CFR 323.4-2, are met. Individual permits were required for discharges up to the headwaters of streams.

4. These regulations were used to define the limits of Section 404(b) authority for this project. First, the main channel and tributaries of Maline Creek were evaluated to determine the location of "headwaters," which is defined as the point upstream of which the average annual flow is less than 5 cubic feet per second. Only two reaches of stream had sufficient flow for this definition to apply; the main channel of Maline Creek to Hanley Road (reaches M1 through M14), and tributary MD to Chambers Road.

5. "Ordinary high water" was then estimated for streams in the watershed. Ordinary high water elevations were not immediately apparent because of the many vertical loessial stream banks that provide no visible mark for such estimation. However, numerous field observations of water levels in the basin, and a knowledge of the ordinary high water elevations of similar streams where a visible mark is apparent, were used to conclude that ordinary high water for Maline Creek (to Hanley Road) and tributary MD (to Chambers Road) is approximately halfway between the channel invert and high bank. Ordinary high water for tributaries of Maline Creek, except MD, was considered to be the same as the ordinary high water elevation at its confluence with Maline Creek. Tributary MD has no tributaries between its mouth and Chambers Road. TABLE J-1 lists the approximate ordinary high water elevations for stream reaches subject to Section 404(b) evaluation in the Maline Creek basin. A more precise estimate of ordinary high water elevations can be determined by looking at PLATES D-214 and D-219.

TABLE J-1
MALINE CREEK
ORDINARY HIGH WATER ELEVATIONS FOR MALINE CREEK
AND ITS TRIBUTARIES

Reach	Ordinary High Water in Feet Above Mean Sea Level
M1	419
M2	420
MA	420
M3	422
M4	424
MB	426
M5	429
M6	430
MC	430
M7	432
MD (mouth)	433
MD (Chambers Road	445
M8	439
M9	441
M10	441
M11	447
M12	460
ME	465
M13	468
M14	470

6. The content and format of the following Section 404 evaluation is based upon guidance furnished in EC-1105-2-97.

SECTION 404(b)(1) EVALUATION

1. Project Description. The proposed plan of improvements for Maline Creek consists of 13 basic features, as follows:

a. 18 aquatic habitat structures
b. 1-2/3 miles of stream bank stabilization
c. 16 sewer modifications
d. 3.29 miles of earth channel enlargements
e. 8 flood control detention basins in upland headwater sites
f. 5 fish ponds in upland headwater sites
g. 212 interior catch basins above the ordinary high water mark

h. 5 bridge replacements with no structure within the ordinary high water mark

i. 2 bridge improvements, expanding the flood passing capability

j. 5.05 miles of concrete floodwall above the ordinary high water mark

k. 3.31 miles of earth levee above the ordinary high water mark

l. 10 miles of trails

m. 77 acres of selective clearing

It is considered that only the first four features involve placement of dredged or fill material that is subject to Section 404(b) analysis. The St. Louis District has concluded that features "e" and "f" above are authorized by the nationwide permit published in 33 CFR 323.4-2, and will not require individual authorization. Discharges of dredged or fill material required for construction, operation, and maintenance of these two features will satisfy qualifying criteria specified in 33 CFR 323.4-2(b). Discharges of dredged or fill material associated with project features "g" through "1" above will be limited to non-wetland areas lying above ordinary high water. Feature "m" above does not involve the discharge of dredged or fill material.

a. Description of the Proposed Discharge Site(s) for Dredged or Fill Material

(1) Location and area extent. (See APPENDIX E, Draft Survey Report.)

(a) 18 aquatic habitat structures - Sixteen of these structures will be placed at 0.5 mile intervals in reaches M1 through M14; 2 structures will be on tributary MD at the same interval. The location of these structures are shown in PLATE F-1.

(b) 1-2/3 miles of stream bank stabilization - The location of these improvements appear in PLATES E-30 to E-57, in association with low level flood buffers or channel enlargement in stream reaches M2, M4, M5, M10, and M12.

(c) 16 sewer modifications - These sewer modifications occur at or near the levee or floodwall sites. These levee-floodwall sites are shown in PLATES E-30 through E-57.

(d) 3.29 miles of earth channel enlargements - These improvements occur at several locations within the project boundaries and are shown in PLATE E-30.

(2) Type of discharge site(s).

(a) 18 aquatic habitat structures - In the bottom or invert of the creek.

(b) 1-2/3 miles of stream bank stabilization - Located on the bank or side slopes of the creek near locations that pose potential erosion problems for structural improvements.

(c) 16 sewer modifications - Modifications extend from the side slopes down to the invert of the creek.

(d) 3.29 miles of earth channel enlargements - Within the existing channel and at new channel locations.

(3) Method of discharge. Placement of material will be by means of heavy earth moving equipment (land-based).

(4) When will discharge occur? Construction may begin in 1990 based on optimum report processing.

(5) Projected life of discharge site(s). The proposed project life is 100 years, estimated as possibly 1990 to 2090.

(6) Bathymetry (if open water discharge). Not applicable. No open water discharge.

b. Description of the Proposed Discharge of Dredged or Fill Materials.

(1) General characteristics of material.

(a) 18 aquatic habitat structures - Constructed of metal wire baskets filled with local quarry rock.

(b) 1-2/3 miles of stream bank stabilization - Constructed of graded riprap with filter cloth (perforated polyvinyl sheet type material) subbase.

(c) 16 sewer modifications - Constructed of reinforced concrete pipe with concrete and steel headwall.

(d) 3.29 miles of earth channel enlargements - Constructed of soil material in the immediate vicinity of the creek.

(2) Quantity of material proposed for discharge. The quantity and type of material required for construction of the improvements are shown in the Cost Estimate Section of this report (APPENDIX E).

(3) Source of material. The sources of the material required for construction of this project are locally available from on site sources and local suppliers.

2. Physical Effects (40 CFR 230.4-1(a)).

a. Will wetlands be lost? Not applicable. There are no wetlands located within the Maline Creek watershed.

b. What will be the effects on the water column?

(1) Light transmission. Light transmission in the creek may be temporarily reduced by increased turbidity levels induced during construction.

(2) Aesthetic values. Aesthetic values will be temporarily degraded at construction sites. The long-term effect of flood plain and large tract preservation and fish and wildlife and outdoor recreation developments should significantly increase aesthetic values.

(3) Direct effects on nekton. The aquatic habitat structures should provide a more diverse habitat in the stream for a net beneficial effect on fish and other nektonic organisms.

(4) Direct effects on plankton. Plankton populations in the creek may be temporarily reduced in numbers and variety because of turbidity increases induced during construction. The aquatic habitat structures, and the erosion-reducing features of the project, should result in long-term increases in numbers and variety of planktonic populations.

c. What will be the significance in covering the benthos as to:

(1) Relative extent of loss. All benthos inhabiting the 3.29 miles of earth channel enlargements will be destroyed. The loss from other actions will be insignificant.

(2) Time required for repopulation. Repopulation should occur within the first year after construction.

(3) Change in benthic community. There could be some increase in diversity due to the introduction of a different substrate (rock) used in aquatic habitat structures and stream bank stabilization.

(4) Effect on other species which are dependent upon the benthos. Insignificant.

d. What will be the change in:

(1) Bottom geometry.

(a) 18 aquatic habitat structures - The bottom geometry will be changed to create an artificial pond constructed in the creek bottom with no significant change to geometry.

(b) 1-2/3 miles of stream bank stabilization - The side slopes of the creek will be degraded to make a suitable foundation for the filter cloth and graded riprap.

(c) 16 sewer modifications - Virtually insignificant changes in bottom geometry.

(d) 3.29 miles of earth channel enlargements - Bottom changed to reflect larger base width and specified side slopes. In some cases existing channel will be used as fill areas for excess material excavated from the channel.

(2) Substrate composition.

(a) 18 aquatic habitat structures - Introduction of limestone and metal to the substrate.

(b) 1-2/3 miles of stream bank stabilization - Introduction of polyvinyl material and stone to substrate.

(c) 16 sewer modifications - Introduction of reinforced concrete pipe with concrete and steel as headwall material.

(d) 3.29 miles of earth channel enlargements - No change except for some mixing of soil materials when placed in channel fills.

(3) Salinity gradients. Not applicable.

(4) Alteration of biological communities due to exchange of constituents between sediments and overlying water? Insignificant.

3. Chemical-Biological Interactive Effects (40 CFR 230.4-1(b)).

a. Does the material meet the exclusion criteria? The fill materials for construction of the aquatic habitat structures, stream bank stabilization, and sewer modifications do not meet the exclusion criteria. The fill materials for earth channel enlargements do meet the exclusion criteria of 40 CFR 230.4-1(b)(1)(iii), namely:

(1) The material proposed for discharge is substantially the same as the substrate at the proposed disposal site;

(2) The site from which the material proposed for discharge is taken is sufficiently removed from sources of pollution to provide reasonable assurance that such material has not been contaminated; and

(3) Adequate terms and conditions will be imposed on the discharge of dredged or fill material to provide reasonable assurance that the material proposed for discharge will not be moved by currents or otherwise in a manner that is damaging to the environment outside the disposal site.

b. Water column effects of chemical constituents (40 CFR 230.41-1(b)(2)). Are contaminants released? If so, at what levels? Sediment analyses are not considered necessary. The physical and chemical properties of aquatic habitat structures, stream bank stabilization structures, and sewer modifications - galvanized metal, limestone quarry rock, polyvinyl filter cloth, concrete, and steel - are well known and not expected to release toxic substances into the water.

c. Effects of chemical constituents on benthos (40 CFR 230.4-1(b)(3)). Insignificant.

4. Description of site comparison (40 CFR 230.4-1(c)).

a. Total sediment analysis (40 CFR 230.4-1(c)). Sediment analysis is not considered necessary. Proposed fill materials for this project are compatible with the maintenance of good water quality.

b. Biological community structure analysis (40 CFR 230.4-1(c)(2)). Community structure studies are not considered necessary for this evaluation. The existing aquatic biological

community is low in numbers and diversity (see APPENDIX A). The aquatic habitat structures should improve the habitat diversity. An increase in biological community diversity is possible.

5. Review Applicable Water Quality Standards. Water quality standards adopted by the State of Missouri and published in the Missouri Code of State Regulations, Title 10, Division 20, Chapter 7, are applicable to the proposed work site. Missouri's water quality standards define the State Clean Water Commission's water quality objectives in terms of water uses to be maintained and criteria to protect those uses, and defines the antidegradation policy. They were developed in accordance with Sections 303(c)(1) and (2) of the Clean Water Act which required that state water quality standards be reviewed and upgraded at least once every three years. Such revisions are pursuant to the national interim goal of protection of fish, shellfish, wildlife and recreation in and on the water by 1 July 1983, as outlined in Section 101(a)(2) of the Clean Water Act. The placement of fill materials in connection with the proposed Maline Creek project will generally comply with state water quality standards. Excessive turbidity levels may be temporarily induced in local areas during construction.

a. Compare constituent concentrations. This is not considered necessary. The fill materials will be compatible with the maintenance of water quality in compliance with State of Missouri standards.

b. Consider mixing zone. Not applicable.

c. Based on a and b above, will disposal operation be compatible with applicable standards? Yes.

6. Selection of Discharge Sites (40 CFR 230.5) for Dredged or Fill Material.

a. Need for the proposed activity. The proposed discharge of fill material is an essential component for constructing the recommended plan of improvements.

b. Alternative sites and methods of discharge considered. A vast array of alternatives were considered and are discussed in detail in APPENDIX B of the Draft Survey Report.

c. Objectives to be considered in discharge determination (40 CFR 230.5(a)).

(1) Impacts on chemical, physical, and biological integrity of aquatic ecosystem (40 CFR 230.5(a)(1)). A temporary increase in turbidity may occur in Maline Creek during construction. Overall, the project is expected to have a net beneficial effect on the aquatic ecosystem.

(2) Impact on food chain. Insignificant.

(3) Impact on diversity of plant and animal species. The potential exists for an increased diversity of aquatic organisms.

(4) Impact on movement into and out of feeding, spawning, breeding and nursery areas. Insignificant.

(5) Impact on wetland areas having significant functions of water quality maintenance. Not applicable. No wetlands are located in the project area.

(6) Impact on areas that serve to retain natural high waters or flood waters. The overall project is designed to exclude flood waters from adjacent lands. The proposed fill will contribute to that flood control.

(7) Methods to minimize turbidity. All permanent and temporary earthen fill will be promptly seeded and properly maintained to prevent erosion. Stream bank stabilization will prevent stream bank erosion, and aquatic habitat structures will help control bottom degradation.

(8) Methods to minimize degradation of aesthetic, recreational, and economic values. The overall project, including the proposed fill actions, is expected to have a significant beneficial effect on aesthetic, recreational, and economic values.

(9) Threatened and endangered species. The proposed action will have no significant effect on threatened or endangered species.

(10) Investigate other measures that avoid degradation of aesthetic, recreational, and economic values of navigable waters. This is considered unnecessary since no such degradation is expected.

d. Impacts on water uses at proposed discharge site (40 CFR 230.5(b)(1-10)).

(1) Municipal water supply intakes. No effect.

(2) Shellfish. No effect.

(3) Fisheries. The aquatic habitat diversity will be enhanced. The potential exists for an increase in quantity and variety of fish species in Maline Creek.

(4) Wildlife. Some disturbance of adjacent wildlife populations would occur both during construction and as a result of increased public use of project lands after construction. However, the preservation and management of flood plain and large tract wildlife habitats is expected to provide a significant beneficial effect on wildlife.

(5) Recreation activities. Project lands will be used for outdoor recreational pursuits throughout the project life, presently projected to be 1990 to 2090.

(6) Threatened and endangered species. No significant effect.

(7) Benthic life. Insignificant. See discussion in item (3), Fisheries, above.

(8) Wetlands. No effect.

(9) Submersed vegetation. No effect.

(10) Size of disposal site. All areas designated for fill under this evaluation total approximately 58 acres.

e. Considerations to minimize harmful effects (40 CFR 235.5(c)(1-71). No significant harmful effects are expected to result from the proposed fill activities.

(1) Water quality criteria. No effect.

(2) Investigate alternatives to open water disposal. Not applicable.

(3) Investigate physical characteristics of alternative disposal sites. Not applicable.

(4) Ocean dumping. Not applicable.

(5) Where possible, investigate covering contaminated dredged material with cleaner material. Not applicable.

(6) Investigate methods to minimize effect of runoff from confined areas on the aquatic environment. Earthen fill will be promptly seeded and properly maintained to prevent erosion.

(7) Coordinate potential monitoring activities at discharge site with EPA. Not considered necessary, due to minimal and essentially beneficial effects.

7. Statement as to Contamination of Fill Material if from Land Source (40 CFR 230.5(d)). There is no indication that proposed fill materials are contaminated or that they will be subject to contamination.

8. Conclusions and Determinations. On the basis of our assessment, I have made a preliminary determination that the proposed fill activities associated with the Maline Creek project are compatible with guidelines promulgated by the Environmental Protection Agency under Section 404(b) of the Clean Water Act (Public Law 92-500, as amended). Our assessment of proposed fill activities included an ecological evaluation following the guidance

in 40 CFR 230.4, in conjunction with the evaluation considerations in 40 CFR 230.5 and 230.3(d); identification and incorporation of measures to minimize adverse effects on the aquatic environment (40 CFR 230.3(d)(1); consideration of the need for the proposed activities, the availability of alternative sites and fill methods, and the applicability of water quality standards (40 CFR 230.5); and an evaluation of effects on wetlands (40 CFR 230.5(b)(8)).

9. Findings. It is our preliminary determination that the proposed discharge sites of the specified features of the Maline Creek project have been specified through the application of the Section 404(b)(1) guidelines. The final assessment and findings will be tempered by consideration of comments furnished by Federal, state, and local agencies, and by interested members of the general public.

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